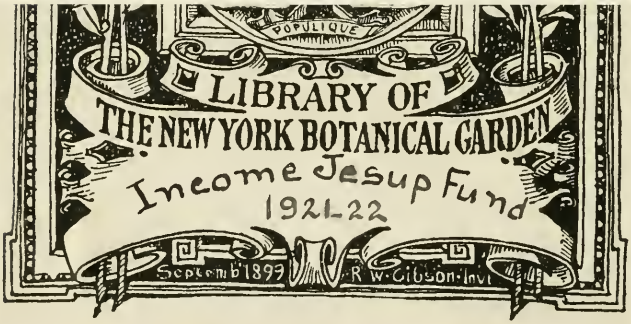
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Vol. I No. 1

The Journal of Indian Botany

EDITED BY

P. F. FYSON, B.A., F.L.S.

Presidency College, Madras



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Subscriptions should be sent to the Hon. Editor,

P. F. Fyson, Esq.,

The Baobab, Teynampet, Madras, S. India.

Intending Contributors are requested to see the note on page 3 of this cover.

THE BAOBAB, TEYNAMPET,
MADRAS,
September 15, 1919.

DEAR SIR,

I am sending under separate cover a copy of the first number of a new botanical journal which has been founded under the name of the " Journal of Indian Botany " for the publication of original papers in Botany which would not naturally find a place in the existing Indian Journals. For there is no other journal in India which could accept a paper on Ecology, Physiology, Histology, or the Cryptogams, except such as might be of agricultural interest. Yet India is so large a country, has so rich a flora, and so varied a climate that there are here ample possibilities of work, the results of which might prove of value to botanists in almost every part of the world.

The number now sent is only the first: the second will be out next month (October), and it is intended to publish ten numbers annually. One can hardly doubt that the Journal will, as it becomes better known, contain more papers and increase in importance.

I venture to suggest, therefore, that you will find it of interest and that it would make a suitable addition to the library of your college or university on account not only of the original papers, but also perhaps of the abstracts which it will contain of papers published elsewhere in India.

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THE

Journal of Indian Botany.

VOL. I. SEPTEMBER, 1919. No. 1.

EDITORIAL

This JOURNAL OF INDIAN BOTANY has been started to provide a means of publishing botanical work done in India, which would not naturally find a home in the existing botanical journals of this country, *e.g.*, the Records of the Botanical Survey and the various publications of the Agricultural Departments. The need for something of this kind has long been felt and frequently expressed, for without doubt much good work has been done in India in branches other than Floristic or Agricultural Botany, which has too often been laid on one side for lack of facilities of publication. The present venture owes its inception in the first place to the enthusiasm of Mr. L. J. Sedgwick, F.L.S., a keen and prolific worker in systematic botany, who, however, is unable on account of his official work to undertake the editorship; and in the second to Mr. T. R. D. Bell, C.I.E., who generously came forward with an offer to guarantee the expenses till the Journal should be so far established as to pay its way, or prove unwanted.

The chief object of the Journal will be the publication of original matter, and in order that any work may see the light without undue delay, the editor is prepared to issue the Journal monthly, provided of course that there is sufficient matter to go to press. At the same time he feels constrained to remind Indian Botanists that if they really want the Journal to live they must support it by sending to him the papers they would otherwise have sent elsewhere.

In addition to original papers we propose to publish abstracts and reviews and of papers which appear in other journals; but since the editor cannot undertake to abstract all, even of those papers which come under his notice—and there must be many that do not—he will be glad of assistance in this. Several botanists have kindly undertaken to abstract papers, but more help is needed, and it is

hoped that these abstracts will be a regular feature of the Journal, and be of use in keeping Indian workers in touch with what is being done elsewhere.

Finally the editor appeals for subscriptions from all botanists in India, and from those in other countries who are likely to find work done here of interest or help; for to justify itself the Journal must pay its way.

Here, then, is a simple statement of our aims and wants in connection with the Journal; Guarantor, Editor and Publisher are prepared to do their share to make the Journal a success, it is up to Botanists in India to do theirs.

The Honorary Editor.

DIMORPHIC CARPELLATE FLOWER OF ACALYPHA INDICA, *L.*

BY

L. A. KENOYER,

Agricultural Institute, Allahabad.

Acalypha indica L. is a common member of the Euphorbiaceæ growing over most of India as a weed on waste ground. It is said by Hooker to grow over a wide tropical area, from the Philippines to Tropical Africa.

The flowers are apparently in spikes; but a closer examination shows that the flower cluster is in reality a racemose cyme, each of the branches from the main axis being a cyme of three or more flowers. The lower branches, which are almost concealed by large bracts, bear trilocular carpellate flowers closely resembling in structure the carpellate flowers of *Ricinus* and the Euphorbiaceæ in general. Higher on the axis and with much smaller bracts are cymes of staminate flowers, while at the very tip without a bract is a peculiar bilaterally symmetrical unilocular carpellate flower which bears a single seed. This flower has three or four sepals which vary considerably in their position, and a monocarpellary pistil. The ovary is a transverse cylinder slightly depressed at either end and resembling a muff in appearance. The attachment of the stalk and sepals is to the curved surface midway between the ciliate-bordered ends. Arising from this point of attachment is the style. It resembles the style of a single carpel of the trilocular pistil except for its basal position and the fact that it is more fimbriate, having six to eight thread-like branches instead of three to five.

As the flower develops into the fruit the upper part of the cylinder elongates so that in its front or rear aspect the fruit is triangular with its apex downward. The edges are extended as hollow auricles which are fringed and rugose. The whole appears like a rhombic leaf bent so that the tip touches the base and enclosing a seed at its center.

To determine the significance of this terminal flower, inflorescence tips of various ages were killed in chrom-acetic acid, imbedded in paraffin, and sectioned. It was found that this flower starts as a

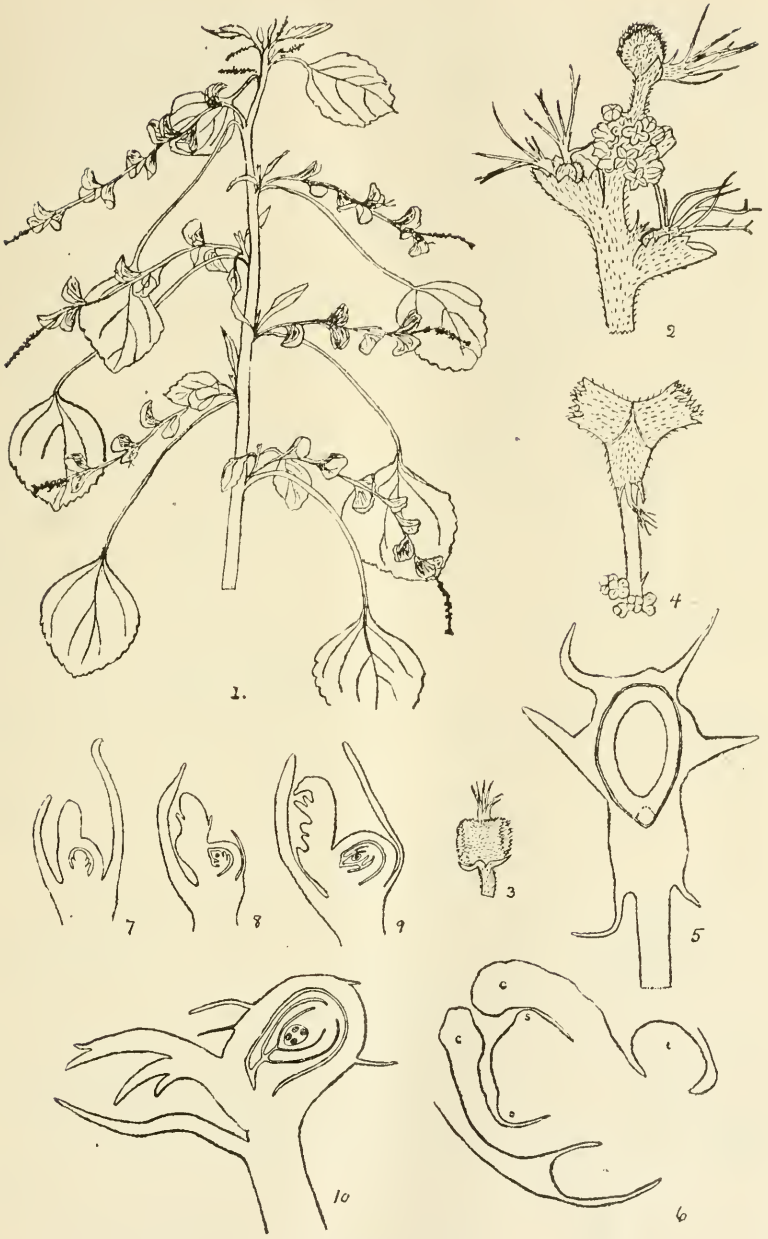
single carpel, there being no trace of other carpels, and that this carpel resembles in structure and appearance one of the three that make up the tricarpellary pistil. In both cases the style is terminal and the ovary orthotropous at the beginning. As development takes place in the monocarpellary flower, one side of both ovary and ovule greatly outgrows the other so that the micropyle of the anatropous ovule faces the style, which appears to come from the base of the ovary. In the polycarpellary flower, the conjunction with other carpels prevents any one carpel bending to bring the style into a basal position. But the ovule becomes bent in the same direction as in the terminal flower, the funiculus being lifted and folded against the ovule by the elongation of the common axis of the three carpels. The result is a half-inverted or amphitropous ovule with the funiculus joining the common axis about one-third the distance from its top, and with the micropyle at the upper end and not far from the base of the style. It will be seen that development in both cases keeps the micropyle near the base of the style in the most favorable position for the ready entrance of the pollen tube.

The obturator, a mass of cells observed by Baillon (1) as growing from the placenta toward the micropyle of certain Euphorbiaceæ, is conspicuous here. We also observe the beak-like tip to the nucellus which was noticed by Lyon (2) in *Euphorbia corollata* and by Schweiger (3) and Weniger (4) in other species of *Euphorbia*.

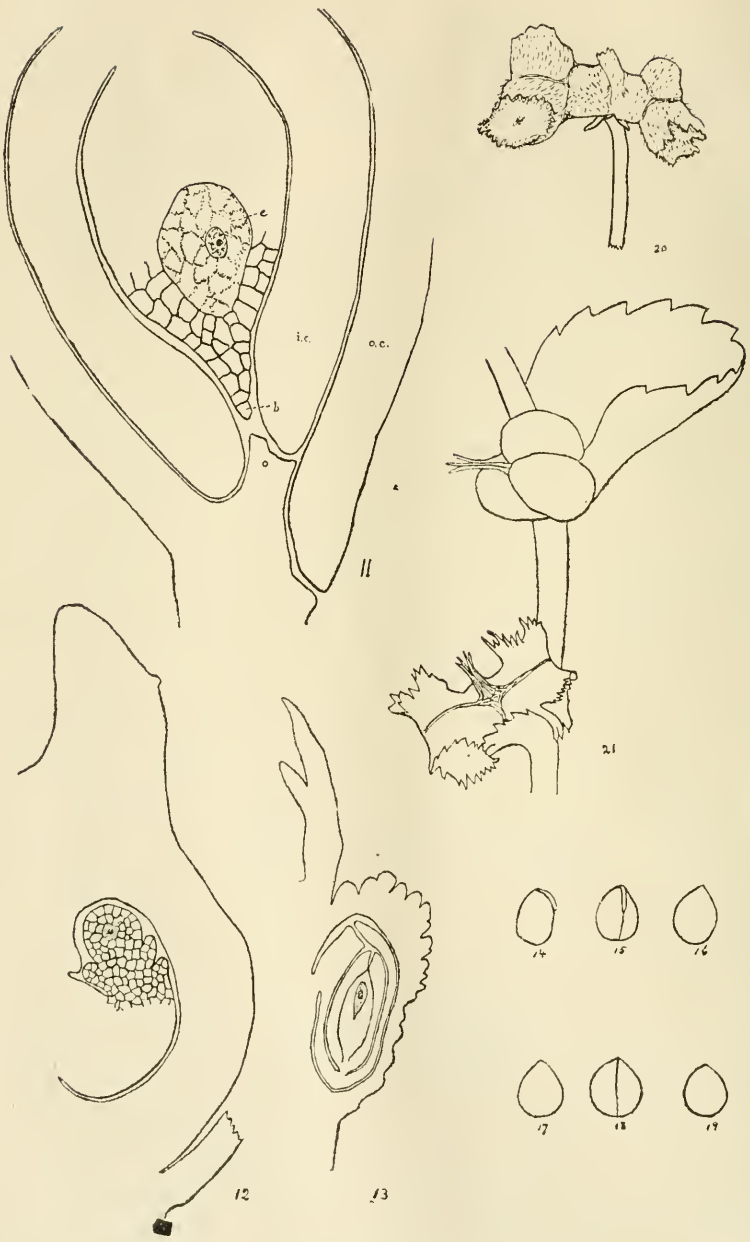
The difference in the shape of the ovary leads to interesting differences between the terminal and lateral seeds. On the lateral seed is a conspicuous white caruncle formed by the turgescence of the outer coat and occupying mainly the space between the funiculus and the micropyle. On the terminal seed, since the funiculus almost touches the micropyle, there is almost no caruncle. On the other hand its raphe is longer, extending the entire length of the seed.

Ten seeds of each type were selected at random from five different plants and were carefully measured. Those from terminal fruits averaged 1.247 mm. long by 1.047 mm. wide, those from lateral fruits averaged 1.447 mm. long by 1.115 mm. wide. The proportion of length to width of the former lot is 1.2 : 1, that of the latter is 1.3 : 1. It is also observable that the thickness of the terminal seed is about equal to its breadth, while that of the lateral seed is considerably less than its breadth.

In the material examined two interesting sports were discovered—one being a double flower of the terminal type occupying a terminal position, and the other a similar flower occupying a lateral position and lower down than other lateral flowers of the usual type.



FIGURES 1—10.



FIGURES 11—21.

Explanation of the Figures.

1. Branch of Acalypha indica *L.* × ½.

2. Single inflorescence, showing side of the terminal flower with the much-branched style is on the right. × 8.

3. Terminal flower, viewed from the rear or face opposite style. × 8.

4. Mature terminal fruit, viewed from the front or style face. × 8.

5. Longitudinal section of an almost mature terminal fruit, showing the ear-like outgrowths. × 20.

6. Young staminate cyme. *C.* sepal, *s*, stamen of terminal flower. 1, lateral flower. × 50.

7. 8, 9, 10. Successive stages in development of a terminal flower. × 50.

11. Stage corresponding to 9 enlarged. *o. c.* outer coat, *i. c.*, inner coat, *o*, obturator, *b.* beak, *c.* embryo sac. × 220.

12, 13. Successive stages in development of a carpel of the lateral flower. 12 × 220, 13 × 50.

14, 15, 16. Side, front, and rear view of seed from a lateral flower. × 8.

17, 18, 19. Side, front, and rear view of seed from a terminal flower. × 8.

20. Double terminal flower. × 8.

21. Similar flower in a lateral position, an ordinary lateral flower above it. × 8.

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THE MYXOPHYCEAE OF LAHORE.

BY

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Probably no other group of the vegetable kingdom has been so much neglected by morphologists as that of the *Myxophyceæ*. In India practically no work on them has been done at all. With the exception of a few stray records of certain Indian species by Schmidle, Hassal, Turner and West, absolutely nothing is known about the Indian Blue-green Algae.

At first sight, one would not think that the Blue-green Algae are found to any large extent in Lahore, but a little careful observation reveals a large variety of them, and in fair abundance. After the rains, that is in the months of October and November, they are at their best, and then again in February and March. Even in such bad months as May and June, or December and January, they are quite easily obtainable; so that one can rightly say that the Blue-green Algae flourish fairly well in Lahore throughout the year. In this connection it might be noted that Lahore is situated in 31° 35′ N. and 74° 20′ E. Its height is 732 feet above the sea-level. The hottest months, namely May and June, have a mean maximum temperature of about 106° F., the actual highest might go up to 120° F. The coldest months, namely December and January, have a mean minimum temperature of 40° F., the lowest never going below 29° F. Rainfall is chiefly confined to the months of July, August and September, and ranges between 8 and 25 inches.

The sources of material for examination are manifold. A large number of the Blue-green Algae are found throughout the year in places, where there is a constant flow of water, such as drains and water-courses. Artificial tanks kept constantly full of water, such as those in the Shalamar and Shahadara Gardens, also form a useful permanent source. Again, after the rains, a few natural ponds and ditches are left by the road-side in the outskirts of Lahore, which take quite a long time to dry up, and are generally found to be full of algal flora. In addition to all these, short-lived varieties are found on ordinary ground or lawns, on which rain or well-water has stood for even a short time. Another interesting source is afforded by the tree-trunks, which are sometimes covered by beautiful varieties after the rain has moistened them.

SYSTEMATIC.* Of the two orders of the *Myxophyceæ*, namely the *Coccogoneæ* and the *Hormogoneæ*, the latter has been much more studied by the writer. Amongst the former, **Chroococcus turgidus** *Kuetz*, (Cooke, *l. c.* p. 204, pl. 83, fig. 2) is very commonly found for the most part of the year, generally sticking to the submerged walls or the floating masses of decaying vegetable matter in stagnant ponds or ditches. It is about 20μ thickness, and is often seen to be dividing into two, or rarely into four.

Gloeocapsa polydermatica *Kuetz.*, is very common amongst the grass on lawns after a little rain or watering. It forms a thick, green layer when moist. Individual cells have a hyaline lamellose membrane, and are about 5μ thick. When dry, the stratum becomes greenish-brown, the membrane of the individual cells also taking on that colour.

Clathrocystis aeruginosa *Henf.* (De Toni, *l.c.* p. 94; Cooke, *l.c.* p. 212 pl. 86, fig. 7) forms a bright green scum on stagnant water, generally where the water is full of waste organic matter such as the Duck Pond in the Zoo. Fronds of various sizes and of various shapes are commonly met with at the same time. Young fronds seem to be solid, but as they grow old they become hollow, and finally clathrate.

Two or three species of *Merismopedia* are fairly common, with their families freely floating in stagnant water, or sometimes sticking to floating masses of decaying vegetable matter.

Of the second orders *Hormogoneæ*, the Cohort *Psilonemateæ* is very well represented in Lahore, while the Cohort *Trichophoreæ* is as yet found to be represented only by *Rivularia bullata* Berk. Of the former, the three families, *Oscillatoriaceæ*, *Nostocaceæ* and *Scytonemaceæ* have been found to be fairly well represented, while no plant of the *Stigonemaceæ* has as yet been discovered.

Oscillatoria princeps *Vauch.* (De Toni, *l. c.* p. 150) is the thickest species of the genus yet found. It generally occurs in dirty drains, carrying off water from road-side water-pipes. Stratum dark green, first attached to the mud and then floating. Trichomes straight, rigid, yellowish-green, about 36μ thick. See Fig. 1.

Oscillatoria tenuis *Ag.* (De Toni, *l. c.* p. 166; Cooke, *l. c.* p. 249; pl. 96, fig. 8) is the commonest *Oscillatoria* of Lahore, found generally in dirty drains and in places constantly wetted, such as in mud

* The classification of the Myxophyceæ followed in this paper is taken from J. B. De Toni's 'Sylloge Algarum', Vol. V., (1907). The species have been identified from descriptions in that book or from descriptions and figures given in M. C. Cooke's British Fresh-water Algae (1882—1884). Exact references are given after each species.

round water-pipes or wells. Stratum thin, bright green. Trichomes radiating and actively oscillating, 4-8μ thick, generally a little constricted at the joints. Two varieties occur in Lahore, one with straight broad apex, and the other with curved and a little attenuated apex.

Oscillatoria terebriformis *Gom.* (De Toni, *l. c.* p. 189) is generally found forming a green scum on stagnant ponds, associated with *Clathrocystis æruginosa* and *Arthrospira Jenneri* Kuetz. Trichomes free swimming, flexible, screw-shaped or in lax spiral, with unconstricted and indistinct joints, 4-6μ thick; apex generally drawn out.

The Sub-family *Spirulineæ* is represented by **Arthrospira Jenneri** *Kuetz.* (De Toni, *l. c.* p. 206; Cooke, p. 245, pl. 96, fig. 1) which, as mentioned above, is generally found associated with *Clathrocystis æruginosa* and *Oscillatoria terebriformis.* Trichomes bright green, elongated, 4-6μ thick. Spirals 10-16μ in diameter, and about 8μ distant. Joints distinctly constricted; cells globose.

Of the Sub-family *Lyngbyeæ*, *Phormidium* is more frequent than *Lyngbya.* **Phormidium ladinianum** *Gom.* (De Toni, *l.c.* p. 218) has been found on tree trunks, especially on that of *Acacia modesta*, associated with *Phormidium Hansgirgi* Schm. and *Tolypothrix byssoidea* Kirchn, Stratum dark green, thin, fibrous. Trichomes straight, flexible, constricted at the joints, 4-6μ thick. Sheath thin, hyaline. Contents granulose, sometimes hyaline in the centre. See Fig. 3.

Phormidium tenue *Gom.* (De Toni, *l. c.* p. 227) generally sticks to the submerged walls of artificial tanks, forming a membranous, expanded, dirty green stratum on the mud. Trichomes long, a little curved and densely intricate, slightly constricted at the joints, 1-2μ thick.

Phormidium Hansgirgi *Schm.* (De Toni, *l. c.* p. 235) is found on tree trunks, associated with *Tolypothrix byssoidea* and *Phormidium ladinianum*, forming a dark bluish-green stratum. Trichomes parallel, 10-12μ thick, with broad convex apex. Sheath hyaline when moist, and dirty brown and fragile when dry. See Fig. 4.

Phormidium Moerlianum *Grun.* (De Toni, *l. c.* p. 236) is found in stagnant water, where decaying vegetable matter is present. It is generally associated with a species of *Oedogonium.* Trichomes long. a little curved, brownish, 9-12μ thick; joints very short. Sheath thin, colourless. Dissepiments granulated. See Fig. 5.

Lyngbya aestuarii *Lieb.* (De Toni, *l. c.* p. 262; Cooke, *l. c.* p. 258 pl. 101 fig. 1) is commonly met with, associated with a species of *Oedogonium*, and forming freely floating greenish masses. Trichomes long, flexuous, blue-green, granular, about 40μ thick; joints very short. Sheath hyaline, clearly lamellose and brownish when old.

The Sub-family *Schizotricheæ* is represented by **Microcoleus vaginatus** *Gom.* (De Toni, p. 374 ; Cooke, p. 258, pl. 99, fig. 2, under *M. terrestris Deson*) which lives commonly on damp mud, such as that in lawns, flower-pots, and around ponds and ditches. Trichomes long, collected in filiform, tortuous fasoicles, enclosed in a common mucous sheath, from the apex of which they come out in a penicillate manner. Dissepiments granulated, Fascicles 75-80μ thick ; trichomes 4-5μ thick.

The family *Nostocaceæ* is represented by **Nostoc commune** *Vauch.* (De Toni, *l. c.* p. 404 ; Cooke, *l. c.* p. 231, pl. 91, figs. 4–7) and *Cylindrospermum majus* Kuetz. The former is found in large abundance in damp soil, even on lawns after a little rain or watering. Colonies are at first globose and resemble *Botrydium*, then they expand and become more or less irregular, but still keeping the outer membrane intact. Trichomes flexuous, loosely intricate ; joints spherical, uniform about 5μ thick. Heterocysts globose, 7μ thick.

Cylindrospermum majus *Kuetz.* (De Toni, *l. c.* p. 424) is occasionally met with, forming a bluish-green, thin expanded stratum on damp mud. Trichomes 4-5μ thick. Heterocysts oblong, 6-8μ thick. Spore cylindrical, 10μ wide, 20-25μ long.

From the Sub-family *Scytonemaceæ*, three species of *Tolypothrix* are commonly met with in Lahore. **Tolypothrix distorta** *Kuetz.* (De Toni, p. 541 ; Cooke, p. 268, pl. 108, fig. 2) is very abundant in stagnant or very slowly running water, such as the broad watercourses of the Shalamar Gardens. It generally forms a very much expanded bluish-green stratum on broad floating, half-decayed leaves, such as those of the water lily. Trichomes and pseudo-branches loosely interwoven, 8-11μ thick ; joints sometimes indistinct. Sheath membranous, thin, sometimes inflated at the base of the branch, hyaline, yellowish-brown when old. Heterocysts 8-9μ thick, and 12-14μ long.

Tolypothriz byssoidea *Kirchn.* (De Toni, B.C. p. 551) forms a dark brownish stratum on the trunks of trees such as those of *Acacia modesta*, and is generally associated with *Phormidium ladinianum* and *Phormidium Hansgirgi*. Trichomes 9-11μ thick, with irregular pseudo-branches, torulose. Sheath thin, yellow or brown, fragile, tubular. Heterocysts oblong, about 16μ long.

Tolypothrix arenophila *West* (De Toni, *l. c.* p. 554) lives on damp coarse mud, such as that in lawns or around ponds and ditches. At first it forms small circular bluish-green, shiny patches, which expand later on. By coalition of several such patches a very extensive stratum is produced. Trichomes flexuous and contorted, densely intricate, about 6μ thick, with few pseudo-branches. Sheath thick,

yellowish-brown, firm, lamellose when old. Contents granulose, refringent. Heterocyst oblongo-rectangular, about 10μ long.

As mentioned above, of the Cohort *Trichophoreæ*, in Lahore only **Rivularia bullata** *Berk.* (De Toni, *l.c.* p. 660) has been found as yet. It forms hemispherical, lobed, gelatinous fronds on damp soil by the river-side. Trichomes 6-8μ thick, bluish-green, a little constricted at the joints, thinned out into a hyaline point at the apex. Heterocyst globose, 6-8μ thick. See Fig. 6.

PERENNATIONS. In this connection, a few observations might very well be recorded. Terrestrial forms, such as *Gleocapsa majus*, *Nostoc commune*, *Phormidium Hansgirgi*, *Tolypothrix byssoidea*, *Tolypothrix arenophila*, generally tide over the unfavourable time by enclosing themselves in their sheaths, which often become much thicker and sometimes lamellose, and take on a yellowish-brown colour. On the return of favourable conditions they come out of the sheath, and multiply.

Resting spores have been very clearly seen in *Tolypothrix distorta* in all the stages of development. Generally a number of cells, about four, fuse together by the absorption of the intervening cell-walls and swell up. The contents take on a separate wall, which becomes firm and yellowish-brown. Many spores are formed in a chain-like series. They are oblong in shape, and 18-21μ by 11-13μ in size. Germination of these spores has not been observed as yet. See Fig. 7.

CONCLUSION. The species of the Blue green Algae, described above, occur quite commonly in Lahore, but in addition to these, there are a few others, which are met with only occasionally; and for that reason have not been yet identified or studied properly.

Explanation of Plate III.

Fig. 1. A small portion of *Oscillatoria princeps*. (× 500).

Fig. 2. A filament of *Oscillatoria terebriformis*. (× 1000).

Fig. 3. A portion of *Phormidium ladinianum*. (× 600).

Fig. 4. A portion of *Phormidium Hansgirgi*. (× 666).

Fig. 5. A portion of *Phormidium Moerlianum*. (× 666).

Fig. 6. Two filaments of *Rivularia bullata*. (× 1000).

Fig. 7. A portion of a filament of *Tolypothrix distorta*, forming resting spores. (× 500).

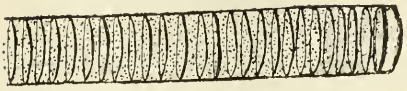


Fig. 1.



Fig. 2.



Fig. 3.



Fig 4



Fig 5.

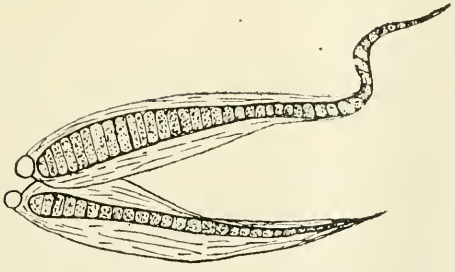


Fig. 6



Fig 7

ON ALYSICARPUS RUGOSUS *D. C.* AND ITS ALLIED SPECIES.

BY

L. J. SEDGWICK, F. L. S.

It is a well-known crux whether the extremely diverse forms of *Alysicarpus* which show a lomentum with the joints deeply and closely transversely rugose belong to one species or several. De Candolle (Prodr. I, 353) described two species,—*A. styracifolius* and *A. rugosus*. Wight and Arnott (Prodr. I, 234) gave three, viz., *A. styracifolius* of De Candolle, and two new ones of their own,—*A. Wallichii* and *A. Heyneanus*. Baker (F. B. I. II, 159) reduced all previous descriptions and all known specimens to one variable species, for which he retained the name *A. rugosus* D.C., making *A. styracifolius* D.C. and *A. Heyneanus* Wt. & Arn. varieties, along with a third variety *ludens* from the specific *A. ludens* of Wallich, and regarding Wight and Arnott's *A. Wallichii* as a synonym of the type. Later floras (so far as known to me) have followed Baker, several other varietal names, however, having been added, viz., *minor* and *pilifer* both of Prain, and probably others.

While not denying that many of our Indian species need reduction, being merely local or edaphic forms, I am disposed to think that the Indian Floras have often on the other hand given a wholly exaggerated impression of morphological variability (as opposed to plastic reaction to environment) through failure to detect the definite characters dividing closely allied species: and this would seem to be the prevalent view at the present time. In particular I am convinced that where in the same habitat two clearly distinguishable forms exist side by side and do not merge they must necessarily be true species. For this reason the field worker is an indispensable complement to the herbarium systematist, inasmuch as he is able to observe the innumerable plants around him, and note their demeanour.

The fact that *A. rugosus* D.C., as understood since the F. B. I., contains more than one species has been forced upon me by field observations at various camps in the Dharwar District during the last three seasons. For instance this winter on the black soil east of Hubli, M. S. M. Ry., two quite distinct plants were abundant as weeds in the fields. Their differences amounted to at least six characters.

Over a wide tract of country there must have been millions of these plants, and out of the enormous number which came under observation during a month and more no individuals were seen which could not be at once allocated (even from horse-back) to one or other of the two types. Now if these types were intra-specific, then their contrasting characters would be allelomorphs. I regret that it did not at the time occur to me to observe the methods of fertilisation ; but there is reason to expect that a typical papilionaceous flower with diadelphous stamens is liable to cross-fertilisation. If so, and if the contrasting characters were allelomorphs, then the occurrence of two separate types each of them exhibiting the whole set of contrasting characters, without the occurrence of even one individual which could be classed as heterozygotic in even one pair of characters, would, I suppose, be an impossibility. However, even if *Alysicarpus* were shown always to be self-fertilised, still the absolute constancy and uniformity of these two sets of characters in the same environment would, I fancy, have convinced anyone who had seen them that we have here two species.

In a single homogeneous tract like the black soil referred to the habit of a species is likely to remain fairly constant. But there is little doubt that most of the species of *Alysicarpus* are highly plastic and react strongly to environment ; and this plasticity is probably the main cause of the confusion which now exists as regards the species with the rugose lomentum, since the superficial (somatic) differences between individuals of the same species are often more obvious than the morphological (germinal) differences between the species.

The systematic notes which follow are based on the field observations referred to as well as on the material in the herbarium of Mr. T. R. D. Bell, C.I.E., and myself, and the material in the herbarium of the St. Xavier's College, Bombay, collected by Father Blatter and Mr. Hallberg, and very kindly placed at my disposal by those gentlemen. This material is all from Western India at various points from Mt. Abu to Madura. It will be seen that I discriminate three certain and one probable species. But I should be far from suggesting that a study of material from the whole of India would not necessitate the recognition of further species. This paper is intended to be suggestive only, and is published in the hope that other workers may find it of use in a further and more complete study of this particular systematic problem. Especially has it been quite out of the question to attempt the unravelling of the intricate synonymy of these plants ; indeed it is doubtful whether this work could be done anywhere but in Europe, where alone the numerous type sheets may still be available.

1. A. styracifolius *D.C.*

Prostrate, or with geniculately ascending branches, (possibly sometimes erect ?). All parts covered both with short pubescence and longer stiff opaque white hairs. General colour of the leaves dark leaden-green, contrasting strongly with the pale racemes. Racemes short, dense. Calyx paler than straw-colour ; segments ovate acuminate, usually with an indurated tip, closely ciliate throughout their length with straight erect white hairs. Lomentum usually exserted.

HERB. SEDGWICK AND BELL.

No.	
1801. Coimbatore,	Aug. 1916.
2010. Black soil fields, Kunemelihalli, Dharwar Dist.	Dec. 1916.
5274, 5278, 5281, 5283 to 5289. Black soil fields, east of Hubli.	Feb. 1919.
5308, 5336. Fields, Sherewad Dharwar District.	do.
5697. Gokak, Belgaum District,	March 1919.

HERB. ST. XAVIER COLLEGE, BOMBAY.

631. Kamban, Madura District,	May 1917,
8843. Tapti R. Banks. Khandesh,	Dec. 1916.
8855. Dangri, Khandesh,	do.
8788. Khandesh,	do.
10086. Muravad, Khandesh,	do.
12385, 12394, 12395. Bhusaval, Khandesh,	do.

This species seems to be much less variable than the others. It is usually fairly easy to pick out in herbaria from the strong contrast between the dark leaves and pale racemes.

2. A. Heyneanus *Wt. & Arn.*

Usually erect, rarely procumbent with geniculately ascending branches often very tall and robust. Stem clothed all over with pubescence and spreading hairs. General colour of leaves ordinary green. Racemes variable in length and density, but usually long lax and narrow. Calyx straw-coloured ; segments oblong subacute, with a few white hairs or not. Lomentum usually prominently exserted.

HERB. SEDGWICK AND BELL.

No.		
2034.	Yelvigi, dry regions of the Dharwar District,	Dec. 1916.
2087.	Kunemelihalli, Dharwar District, on black soil,	do.
3675.	Forty miles south of Dharwar,	Feb. 1918.
3840.	Chabbi, Dharwar District,	do.
5269, 5270, 5272, to 5277, 5279, 5282.	Black soil fields, east of Hubli,	Feb. 1919.
5313 to 5315, 5337.	Fields, Sherewad, Dharwar District,	do.
5441.	Dangs, Gujarat (very robust),	do.
5486.	Tegur, Dharwar District (very robust),	March 1919.

HERB. ST. XAVIER COLLEGE, BOMBAY.

10195.	Taver, Khandesh,	Dec. 1916.
22684.	Antorli, Khandesh,	do.
8813, 8814,	Tapti R. Khandesh,	do.
8787.	Antorli, Khandesh,	do.
10102.	Paldhi, Khandesh,	do.
8853.	Khandesh.	do.
8852.	Tapti R. Khandesh,	do.
8844.	Muraval, Khandesh,	do.
9376.	Lina Hill, Nasik,	Sep. 1917.
8784.	Bombay Island, (short, but with v. lax racemes),	Nov. 1916.
8786.	Igatpuri, Western Ghats, (a form similar to the last),	Jan 1917.
8805.	Igatpuri, (tall and with v. lax racemes),	do.
12849.	Turanmal, Satpuras, Khandesh, (an old state, very robust with *very* long racemes).	Dec. 1918.

This species is highly variable in habit.

3. A. rugosus: *D.C.*

Usually prostrate, but sometimes erect. Stem glabrous except for a single alternating line of oppressed ascending hairs. General colour of leaves ordinary green. Racemes short dense. Calyx straw-coloured; segments long, oblong, subobtuse, glabrous, or ciliate at the tip only with short, often purplish hairs. Lomentum usually inclined.

HERB. SEDWICK AND BELL.

1846.	Mugad, Dharwar District,	Oct. 1916.
2155.	Dharwar,	Nov. 1916.
4366.	Dharwar,	Sept. 1918.
4438.	Konankeri, Dharwar District,	Oct. 1918.

HERB. ST. XAVIER COLLEGE, BOMBAY.

No.	
12858 and 12827.	Sea-shore, Alibag, Konkan (Coll. by Moses Ezekiel). Feb. 1917.
12862.	Rice-fields, Alibag, (Coll. as the last), do.
8798.	Salsette, Bombay, Nov. 1918.
8778, 8774 and 9383,	Mt. Abu. Oct. 1916.
8848.	Bombay, Nov. 1916.
8834.	Salsette, Bombay, Sept. 1916.
8803.	Purandar Fort, Poona District, Dec. 1917.
12829.	Poona,
9370.	Bassein, North Konjan (tall), Sept. 1918.
9385.	Bassein, (tall, but with short racemes), Sept. 1917.
12686 and 12688.	Campoli, (v. tall, with racemes 2 inches long), Oct. 1918.

4. A. ludens *Wall.* (*probably*).

Tall, erect. Stems with line of hairs as the last. General colour of leaves ordinary green. Racemes exceedingly long and lax, with distant flowers in pedecillate clusters.

HERB. ST. XAVIER COLLEGE, BOMBAY.

No. 12691. Khandala, October, 1918.

A working clavis would be as follows :—

Stems pubescent and with spreading hairs,

Leaves dark leaden-green, racemes dense, calyx segments acuminate, strongly ciliate A. styracifolius *DC.*

Leaves ordinary green, racemes lax, narrow, calyx segments subacute, with or without a few hairs . . A. heyneanus W. & A.

Stems glabrous except for an alternating line of oppressed ascending hairs,

Racemes short, dense A. rugosus, *DC.*

Racemes very elongate, lax, with distant fasicles of pedicillate flowers A. ludens *Wall.*

It is necessary however to remark that with age both the vestiture of the first two species and the line of hairs of the last two are deciduous.

NOTE ON THE ŒCOLOGY OF SPINIFEX SQUARROSUS *L.**

By P. F. Fyson, B.A., F.L.S., and M. Balasubrahmanyam, B.A.

The question discussed in this paper arose in the course of an investigation into the water and soil-relations of the marine strand vegetation of Madras. One of the most important species of the strand formation is *Spinifex squarrosus* L. It occurs on low sand-dunes as close as 20 yards only from the sea, but always raised a few feet above high-tide level. It usually grows by itself, but in open patches *Cyperus arenarius* Retz. and *Launæa pinnatifida* Cass, sometimes occur.

The plant spreads over the sand by horizontal shoots which root at the nodes, usually beginning with the second and third node from the growing end. The adventitious roots are thick and run more or less vertically downwards for one or two feet, with only small rootlets. Root-hairs are conspicuously developed on the oldest part near the surface of the soil and seem to be persistent there. A few inches below the surface of the ground there are usually none, or only shrivelled dead hairs, and the root is sometimes thinner because of the exfoliation of the outermost layers of the cortex after the formation of an exodermis. The youngest part has no root-hairs, as a rule; the root being quite smooth for one or two inches behind the tip, then becoming slightly lumpy on account of branch roots pushing out from below, but still without any sign of root-hairs.

If a plant be dug up without breaking the roots, and grown in a jar with some roots in water, root-hairs appear on young roots close behind the growing point, but not on older roots.

Sections of this lowest region shows the root surrounded by a highly refractive substance, which is apparently secreted by the cells of the piliferous layer. This layer and its secretion can be traced quite easily under the root-cap back to the earliest stage in the differentiation of root-cap and piliferous layer. The cells are at first isodiametric but soon become elongated radially, taking on the general appearance of secretory tissue. There are no intercellular spaces, the cells are narrow the protoplasm is dense without vacuoles and the nucleus large and situated about the middle. The outer wall is irregular in outline, and beyond it the secretion is marked by

* Paper read at the Indian Science Congress, 1919.

tangential and also by radial lines, which latter appear to be continuations of the middle lamellas between the cells, (fig. 3.) The tangential lines are clearly due to stratification of the substance produced by successive changes in its composition affecting its refractive index, for they are progressively further apart and fainter, and the presence of the radial lines clearly indicating the lateral limits of each cell, shows that the secretion or modification of each cell takes place independently of those of contiguous cells.

The secretion does not take up any of the ordinary protoplasmic stains, such as eosin, osmic acid, or hæmatoxylon; nor could we obtain any reaction with methyline-blue, Schultz solution or iodine.

We conclude that the secretion is due to a modification of the cell-wall, and though controlled and brought about by each cell independently, is not a direct product of its protoplasm. But that it is not a gum or mucilage in the ordinary sense is shown by the fact that it does not swell and dissolve in water at the ordinary temperature, nor take up any cellular stains nor show any cellulose reaction.

The Root-hairs.

As stated above, the root-hairs are found only on parts of the root near the surface of the sand. A few inches down they are cut off by the exodermis, which is formed as usual in monocotyledons, and shrivel up. But near the surface there is no exodermis, and the root-hairs formed while that part was still young persist apparently indefinitely.

The Regions of the root.

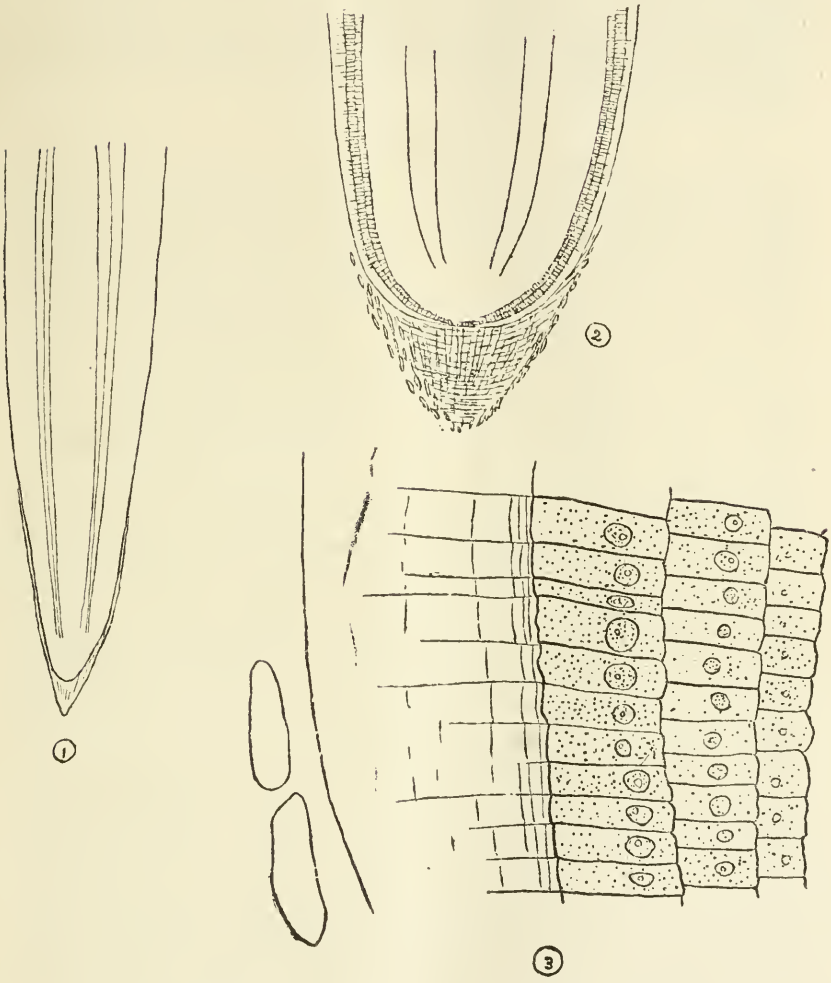
There are three regions in the root:—

I. From the tip to the region of the exodermis the surface is covered by the secretion. This may be two to six inches long and the surface is white, smooth and glistening.

II. In the region of the exodermis the surface tissue is dead and brown. It is in this region that the short rootlets are found.

III. From the exodermal region to the surface, for a length of two or three inches as a rule, the piliferous layer remains fresh, the root-hairs persist and adhere firmly to grains of sand.

The existence of a secretion by the piliferous layer has been noted, we believe, in only a few grasses, which grow in the Algerian Sahara. The chief of these is *Aristida pungens*. R. Price (2) who has examined the secretion, pointed out that in *Aristida* it binds together the sand particles with a tubular sheath into which root-hairs run and are thus enabled, probably, to take up moisture from a larger volume of sand.



1. Longitudinal section of root. 2. Longitudinal section of the tip magnified showing the layer of secretion. 3. Small part of some magnified showing to the left two loose cells II of the rootcap. The secretion shows striation tangentially and readily.

With *Spinifex squarrosus* no tubular sheath is formed, for the secretion does not cause the sand particles to adhere. It appears to act rather as a lubricant or perhaps as a resisting layer to protect the piliferous layer from damage by sharp grains of sand. Spinifex is not related closely to any of the grasses noted by Price as possessing the mucilage layer. The genus consists of only four species, occurring on sandy shores of India, Malaya and N. Australia.

The Water-supply.

Every one knows that sand a very few inches below the surface is damp, as also is any ordinary soil. With ordinary clay or loamy soil this is usually taken to be due to an upward movement from low levels of water drawn up by capillarity through the fine cracks developed by the drying of the soil. This water being continually dried at the surface of the ground. There may be a slow upward movement of water also through sand; but it is very slow. This was determined by us both in the laboratory and in the sand of the beach. In the laboratory two wide glass tubes were filled with dry sand, the lower end closed with muslin and the tubes supported with their lower ends, one in fresh water, the other in salt water. At first the rise of water as shown by the darkening in colour of the sand was rapid, but after the first day the rate fell off and after seven days the level was practically stationary at 24 cms; a slow rise went on for several days till it reached 30 cms. Then no further rise was noted. There was no appreciable difference between the two tubes. The experiment was continued for $4\frac{1}{2}$ months without any change in the level of the dampness being seen. It came to an end with the rotting of the muslin holding in the sand.

In another series of experiments 8-inch drain pipes were sunk in sand in an enclosed space but open to the air. The pipes were 36 inches long. They were filled with dry sand, and some left open, others closed at the top. No appreciable rise of water could be detected after periods of three to six weeks except in one case where the sand had a musty smell and was slightly more damp below than above, pointing to a rise of water from below. Heavy rain had fallen and the sand outside had been saturated, so that the water might have come up as much by hydrostatic pressure as by capillarity.*

* The use of pipes in this way has been objected to by Olsson-Seffer (1) on the ground that no lateral movement of the air enclosed in the pipe is possible as would, he considers, occur in nature, and that the free movement of the water would be prejudiced thereby. But a little consideration would show that in a homogeneous medium of practically limitless extent (as the sands of the seashore) there can be no balance of lateral air-movement inwards or outwards from any imagined volume, and that it is therefore per-

Other workers have observed the same thing, that water does not rise by capillarity in sand; the explanation probably being that there are no capillary tubes formed as in a fine grained clay. The dampness of the sand just below the surface is then not due to a rise from below.

The only other source of water is from above, as rain or dew; and it seems clear that the water in sand even by the sea is not salt water drawn up from below nor even brackish but quite fresh rain water, preserved by the inability of the sand to draw it up to the surface when it would quickly be dried by the sun.

To test this point, we dug pits in the sand till free water was obtained, the depth varied from 2 to 6 feet. The salt in the water was estimated by standard silver nitrate solution. Samples were taken from different parts of the beach with the following results:—

Plant growing	Salt.
Cyperus arenareus	...0·2—0·5 per cent.
Do. with Launæa pinnatifida ...	0·25 ,,
Hydrophylax maritima	0·35 ,,
Spinifex squarrosus	0·85 ,,
(No plants) near sea	6·3 ,,

It will be seen that except on the narrow stripe which is periodically inundated by the sea, the salt-content is very low. It should be noted that the water obtained at, say, 3 feet is not all water which has sunk down from above but some naturally free at that depth. The sinking is clearly seen when the pit is dug. It seems therefore that *Spinifex squarrosus* and other strand-formation species are not halophytes at all as suggested by Schimper (3) Warming at one time, (4) and others, but rather xerophytic psammophytes, depending for their water-supply on the rain-water and dew retained by the sand. The former, it may be noted, though it sinks through the surface layers almost or quickly as it falls, would not pass through the lower layers quickly, for the sand on these low beaches must be saturated at no great depth by the sea-water which has filtered through. As regards dew we have noticed, during the hot weather, in the early morning before sunrise, distinct deposits of dew on the seaward face of every little lump of sand, e.g., the sides of a foot-print and round plants, as if deposited when a slow moving moisture-laden breeze passing over the cooling sand was delayed by the small obstruction. The accumulated affect of this dew, slight as it is, would keep the sand below the surface damp and supply fresh water to plants whose root-hairs are near the surface.

fectly justifiable to draw conclusions from experiments with definite volumes enclosed in non-porous pipes.

Nor are strand-plants however ordinary xerophytic psammophytes. Psammophytes are as a rule deep rooted, and draw on deep-lying water for their supply. These strand-plants do not. Their roots do not grow deep, and in Spinifex at least the root-hairs are, as we have seen, close to the surface and depend apparently on water close to the surface of the ground. This water would, we have seen, be fresh. A certain amount of salt must be blown in from the sea as spray and this would be leached though the surface layers by the next shower of rain down to a certain depth. Perhaps this accounts for the formation of an exodermis and the absence of root-hairs on the lower roots of *Spinifex squarrosus*.

Finally there is another condition different from that of either a desert or sand-field. The air blown across from the sea is damp. It is never dry by the sea, except when the land breeze blows strongly it is damp close to the water. The strand-plants therefore are xerophytic in the sense of having to depend on very little fresh water, but in regard to the water lost by evaporation from the leaves have much less to fear than even mesophytic inland plants. They are surrounded by air as damp as that round a lake. They are not halophytes. They are not xerophytes in the ordinary sense, but subject to the peculiar condition of a shortage of water available to the roots, yet without liability to extensive loss from the leaves. Perhaps their chief physiological characteristic is therefore the ability to carry on metabolism with a minimum of water passing through the system.

As regards the xerophytism of strand-plants, Kearney (5) came to similar conclusion after analysis of the salt-content of the soil. He found that seashore sand contains less salt than some cultivated soils. Kearney insists on the xerophytic character of plants as being due to dry winds and dry sand. But a distinctly moist air seems in Madras to be the rule near the sea.

Literature Cited.

(1) *Olsson-Seffer*. New Phytologist VIII (1909), p. 38.
(2) *Price, R.* New Phytologist X (1911), p. 328 *et seq.*
(3) *Schimper, A. F. W.* S. B. K. Preuss, Akad, Wiss., 1890, pp. 1045-1062 extr. in J. R. M. S. 1891, p. 214.
Plant Geography, p. 184.
(4) *Warming E.* Œcology—Eng. Ed. (1909), p. 227.
(5) *Kearney, T. H.* Bot. Gazette, XXXVII (1904), p. 424.

CURRENT LITERATURE.

Critical Notes, Figures, new Indian Species, etc.

Trichodesma Indicum *Br.* and **T. amplexicaule** *DC.* In a note in *Rec. Bot, Survey India VI (1919) p. 347*, L. J. SEDGWICK points out that these two species, often confused, are really quite distinct, there being differences in hibit, in the leaves, in the calyx, corolla, stamens and fruit. Confusion has been due to Roth describing as T. amplexicaule what is really a form of *T. indicum* Br. The chief differences are illustrated in a plate, and the paper is a good example of what can be done in clearing up mixed species, by careful observation, even without recourse to type sheets.

Fumaria indica *H. W. Pugsley* Sp. Nov., *Proc. Linn. Soc. XLIV (1918)* No. 298, p. 313, hitherto included in *F. parviflora* sub-sp. *Vaillantii* in F. B. I. 128 (1872).

Impatiens Kleiniformis *L. S. Sedgwick* Sp. Nov. *Records of Bot. Sur. India, VI (1919) p. 351.* Very close to *I. Kleinii* Wt. and Arn., but distinguished by the lives of pubescence on the pedicels, the sessile upper leaves with cordate base, and the absence of glands. *Dist.* Western Ghats at 1,600 ft. Castle Rock. Flr. August.

Vernonia Fysoni *Calder*, Sp. Nov. *Rec. Bot. Sur. India. VI (1919) p. 343* (with plate). Allied to *V. Wightiana* Arn. and *V. comoriensis* W. W. Smith, but distinguished by the glabrous obtuse involucral-bracts, glandular 10-ribbed achenes, and the absence of outer series of pappus hairs. A tall subscandent undershrub with dark upper and very white tomentose under surface to the leaves. *Dist.* In light sholas at Kodaikanal, Pulney Hills 7,000 ft.

Habenaria (§ Ate) multicaudata. *L. J. Sedgwick.* Sp. Nov. *Rec. Bot. Sur. India VI (1919) p. 352.* 'A distinct and curious species strongly characterised by the fantastic filiform appendages and enormous anther cells, projecting beyond the flower when it is held in profile.' *Dist.* North Kanara, near Karwar at 1,500 ft. Flr. Sept.

Asparagus Fysoni *MacBride*, Nom. Nov. *Contr. Gray Herb. Harvard Uniu. (1918) p. 17*, for the Nilgiri and Palni plant hitherto known as *A. subulatus* Steud. et Baker (1875), which specific name had been given previously to a S. African plant by Thunberg, *Prod. Pl. Cap. 66 (1794)*.

Primula chasmophila *Balf.* (from Bhutan) is figured in *Curt. Bot. Mag. t. 8791 (1919)*.

Primula tibetica *Watt.* (Sikkim and Bhutan) is figured in *Curt. Bot. Mag. t. 8796.*

Ipomoea dasysperma *Jacq.* (Simla, Rohilcund and Deccan) is figured in *Curt. Bot. Mag. t. 8788.*

P. F. F.

The Genus Oxalis in India.

C. C. Calder. The Species of Oxalis now wild in India. *Rec. Bot. Sur. Ind. VI. (1919) pp. 326—341 with 7 pl.*

Of the nine species now well established four are tropical American, two

South African, one North Temperate, one Himalayas, and the last Cosmopolitan. Three of the species, *O. variabilis* Jacq., *O. pes-caprœ L.* and *O. pubescens* H. B. & K., are reported in India only from the Nilgiri and Pulney Hills; *O. tetraphylla* occurs there, but also in Assam; *O. latifolia* H. B. & K. and *O. corymbosa* DC., both in S. India and on the Himalayas, two others *O. Acetosella* L. and *O. Griffithii* Edgew. and Hook, f., belong in India to Assam, Khasia and the Himalayas. *O. corniculata* L. is widely distributed. An artificial key is provided to facilitate the recognition of the species, and there are 7 excellent full-page plates. The paper is a record of the occurrence of these weeds in India, which will probably be of very great interest in years to come, when considering how much some of these species have spread to the annoyance of planter and gardener alike, it is probable that the distribution of some at least will be much more general.

P. F. F.

Flora of New Guinea.

Ridley, H. N. The Botany of the Wollaston Expedition to Dutch New Guinea, *1912-13. Trans. Linn. Soc. 2nd, Ser. IX. I pp. 1—269 and 6 pl.*

This the second expedition organised by Mr. A. F. R. Wollaston to New Guinea, was to the Nassau range drained by the Utakwa river. The country traversed was of the wildest description, and in the absence of maps and names the various camps have to be indicated by numbers. The route followed was for some 28 miles up the Utwaka river or its tributary, then over much broken limestone, along ridges sometimes only 4 to 5 ft. wide, or descending over a thousand feet to cross some stream. The nature of the going may be guessed from the simple statement that as much as six miles were done in the earlier marches, but later they shortened to little more than two. Oaks occurred at 6,000 ft., and mixed forest densely clothed with moss and reeking with moisture, and at about the same height a large fruited Pandanus. At 8,000 ft. Casuarinas draped with moss were the dominant feature of the vegetation. The limit of trees was reached at 10,900 ft., above which the rock was too steep to support large growths, and just below the snow line the last flower met with was a daisy (Myriactis).

Mr. Ridley divides the country botanically into four regions: (1) the coast region, up to 500 ft., where the forest is swampy and dense and the flora mostly Malayan. (2) the foothill area, from 600 to 3,000 ft. (on light coloured limestone, coral rock or gravel), where the flora is chiefly Malayan. Here occurred the Anonaceæ, Garcinias, Olacineæ, and Icacineæ (except one species of Gomphandra) *Gardenia, Ixora, Webera, Dioscorea, Saccolabium* and *Burmannia* to mention only a few of the genera. A flora which reminds us of that of the uppermost slopes of the mountain of South India at 5—6,000 ft. (3) The frontal mountain zone, to 8,000 ft. and more, with palearctic forms mixing with the Malayan, *e, g. Viola, Oenanthe, Hypericum, Evodia, Ischœmum, and Dodonea.* (4) The main range where, from 6,500 to 8000 ft., Casuarina trees and Violets were the most noticeable features. In the open country were Orchids, *Myriactis, Anaphalis, Astibe,* and *Rhododendrons.* Between 9,000 and 11,000 ft., bushy Vacciniums and Rhododendrons formed a bushy jungle densely overgrown with mosses and very difficult to traverse. At 10,500 grew the curious Pine-like *Podocarpus papuanus,* but above the rocks were so steep that but

few plants can grow. Rhododendrons grew however to 13,000 ft. Among the plants of this region were species of *Achronychia*, *Pilea*, *Elatostema*, *Rubus Impatiens*, *Symplocos*, *Habenaria*, *Ilex*, all of which genera occur on our South Indian mountains at much lower levels. The flora falls into three groups, an Australian, an Antarctic and a Palaearctic.

Over 500 new species are described, and it is considered that New Guinea with its adjacent islands should be considered a " distinct region of its own with a large endemic flora revised with derivatives from Malaya, Australia, and Pylynesia, and, possibly through the Philippines, from the temperate regions of the North." P. F. F.

Ecology.

McLean, R. C. Studies in the Ecology of Tropical Rain Forest. *Journal of Ecology VII. (1919) pp. 5—59.*

This very interesting paper is the first of a series on the ecology of the tropical Rain forest (as developed near Rio de Janeiro). It is a record of careful work and full of suggestive ideas. Records were taken by self-recording instruments of the humidity inside and outside the forest, the former at both a low-level of 1 metre, and a high level of 4 metres, above the ground. The low-level instrument as might be expected showed much small range of variation than the high, and at the latter level the humidity was greater on the whole but much more variable than that in the city of Rio. The incessant variations in humidity the author puts down to the effect of flecks of sunlight piercing the canopy of leaves, and he considers that these variations have a marked effect on the ecology of the under-growth. Elaborate calculations and measurements of the diffusion capacity of the stometa, the volume of inter-cellular spaces in the mesophyll, and the area of cross section of the xylem portion of the vascular bundles of the petiole, in shade and in sun plants, are given, and show that in these plants of the under-growth capacities for absorption and conduction of soil-water are developed only on a low scale.

They possess no adaptation towards increasing the amount of transpiration, but are commonly protected by a thick cuticle. This may be explained as due to the frequent short periods of insolation by sun-flecks which by lowering the humidity, in conjunction with the fact that the chlorophyll in shade leaves is more exposed to their influence than in habitual heliophytes, may cause the loss of water to be greater than the roots can supply. This failure to obtain more water from the soil " seems to point to edaphic factors antagonistic to absorption." The author goes on to say that a shortage of mineral matter might be expected, but examination shows that there is a higher content of ash in relation to the weight of assimilates than in helophytes ; so that the absorption of mineral salts appears to be independent of foliar evaporation. In other words the roots exercise a selective action. This of course is no new idea. Among other interesting points touched on is the effect of a nyctitropic position on transpiration, where the author finds to be negligible, and to have no significance in regard to water-loss. He thinks that the vertical position may prevent the closing of the stomata by too rapid transpiration during the early sunshine hours when assimilation should be active. Another is the large amount of moisture transpired

by the red leaf of *Acalypha* as compared with another sun-plant—*Passiflora*—and from this he is led to consider (somewhat inconsequently perhaps since the *Acalypha* was a sun plant) that a red coloration of the leaves of the undergrowth may possess the same biological significance as that of Red Algæ—to enable arc to be made of the green light which filters through the leaves of the forest. A third observation worth nothing is as the so-called drip-tip, which as developed in this forest he considers has not the signifiance ascribed to it by Stahl in Java, the nature of the surface having more effect on drainage than this shape of the leaf. In this connection reference may be directed to a paper by L. S. Sedgwick who offers an explanation of the existence of acuminate apices in the ' Indian Forester '.

P. F. F.

Prothallia of Lycopodium.

C. J. Chamberlain, Prothallia and Sporelings of three New Zealand Species. *Botanical Gazette, Vol. LXIII, No. 1, pp. 50—64.*

The author gives short resume of the literature of the subject, followed by notes on *L. laterale*, *L. volubile*, and *L. scraiosum*, collected in New Zealand. He finds a green leafy prothallium, with protocorm developed, only in the first, which is a terestiai species. The other two species are epiphytic, and the prothallia are subterranean, with no protocorm. He suggests that this differentiation occurs throughout the genus : and that the green leafy prothallium represents the original type, and that the change to the suprophytic subterranean type occurred in consequence of a delay in germination (some spores require from 6 to 8 years) which allowed only those spores that had reached some place of safety, *i.e.*, had been buried, to produce plants.

E. A. Spressard gives (l.c. pp. 67—78) a very interesting account of the finding of prothallia of *L. clavatrum*, *L. obscurum*, *L. annotinun*, and *L. lucidulum*, nearly all quite close together, in an open space near Marquette Michigan. They were found only on small knolls covered partly by *Polytrichum* and partly by a grass, or sometimes almost bare. He suggests as a reason for this that such spores as were carried and fell on these spots were first of all beaten into the ground by rain, then covered by the shifting sand, and finally conveyed to a favourable depth by percolating water. This theory worked well or guide to where to look for the prothallia. The paper establishes the fact that prothallia have been found in America, and announces the discovery of two new species of prothallia—*L. obscurum* and *L. lucidulum*.

P. F. F.

Algae.

Hybrids of Spirogyra.—E. N. Transeau[1]. (" Hybrids among species of Spirogyra." *American Naturalist, March-April 1919*) has published a paper recording the results of his experiments on hybridization in species of Spirogyra, especially between *S. communis and S. varians*, and *S. varians* and *S. porticulis*. He finds that hybrid zygospores may be formed between species even though they have very different vegetative and spore characters. The nuclei of the gametes do not fuse until after the zygospore-wall matures. The form of zygospore is determined entirely by the female gamete. Filaments derived from hybrid zygospores show their hybrid character in the dimension of filament, character of sporiferous cell and the form of zygospore.

Observations on Euglena Deses.—ROSE BRACHER ("Observations on Euglena deses". *Annals of Botany, January 1919*, has studied the effect of external factors like light, tidal flow and temperature changes on the movements of *Euglena Deses*. She finds that in darkness, at night or at the tidal time the Euglenæ burrow under the surface of the mud. As for the temperature, the Euglenæ are active at any temperature between 2·5° C. and 25° C., outside which movements are arrested. The optimum temperature is 15° C.

Cytology of Tetrahedron minimum.—A. Br.—G. M. SMITH ("Cell-structure and autospore formation in Tetrahedron minimum, *A. Br.*" Annals of Botany, October 1918) has published an illustrated account of the cell-structure and autospore formation in *Tetrahedron minimum*. The young cell contains a single nucleus and a pyrenoid. Repeated mitosis may result in 8 nuclei within a single cell. Autospores are formed by progressive cleavage, the nuclei increasing in number at the same time, resulting in four, eight, sixteen or thirty-two uni-nucleate proto-plasts, each of which finally becomes an autospore. The pyrenoid disappears after the first cleavage, new pyrenoids being formed *de novo* in the young autospores.

Conjugation of Zygogonium ericetorum, Kutz.—W. J. HODGETTS (*New Phytologist, December 1918*) has carefully studied the process of conjugation in Zygogonium ericetorum. His observations confirm De Bary's account of conjugation in this alga. Greater part of the protoplast passes into the protuberance and is there formed into a sort of gametangium by its cutting off a curved partition wall. Each gamete secretes a thin wall round itself. Thus, before fusion, each gamete is surrounded by a double investment. Inner walls become only locally absorbed during the fusion and unite to form a continuous membrane round the zygospore, which persists as the outermost layer of its wall. Azygospores were also observed. Relation of *Z. ericetorum* te *Zygnema pachydermium* West, is discussed and the writer snpports the retention of the genus zygogonium on the basis proposed by De Bary (1858), and accepted by Mille (1897, 1909). S. L. G.

Morphology and Histology.

Dudgeon, Winfield. The Morphology of Rumex cripus, *Bot. Gaz., LXVI 5, pp. 393—420, 7* figs.

In this paper the author gives a detailed account of the development and histology of the flower of *Rumex crispus*, as part of a study of the morphology of the whole plant. He finds that in well developed flowers the development of the organs and of the embryo-sac and pollen grains follows the course usual in dicotyledons, with only slight variations. In the ovule the archespore is the terminal cell (below the epidermis) of a definite axial row. It divides into an upper cell which forms a 4-celled cap, and a lower cell, the embryo-sac mother-cell. This divides into a linear or nearly linear axial tetrad, the lowest cell of which becomes the embryo-sac. The haploid chromosomes in the division of the mother cell are 32 in number. The chief interest in the paper lies in the author's account of the very widespread degenerations which occur at almost any stage in the growth of the floral organs. These degenerations may, he finds occur (a) in any or all of the anthers, at any stage from the spo

rogenous initial to the mature pollen grain, and may involve only the sporogenous tissue and its products, or the entire anther ; (b) in the ovary at any stage from the functioning megaspore to the maturing fruit, and may involve only the embryo-sac, or both embryo-sac and ovule, or the entire ovary; (c) in entire inflorescences. The degeneration is accompanied by, and probably caused by, the formation of a definite abscission layer across the peduncle, whereby the floral organs are cut off from nutriment, and is so common that functionally perfect flowers are rare. As a result of such degenerations four types of mature flowers are produced (a) physiologically staminate (the ovary being functionless) in which the pollen may or may not be functional ; (b) physiologically ovulate, the stamens having been completely eliminated by degeneration ; (c) bisporangiate, having both stamens and ovary functional (very rare); (d) completely sterile, having functionless ovary and stamens completely eliminated. The author discusses shortly the bearing of these facts on the origin of dicliny, which he is inclined to consider may be due in other species also to gradual degenerations, and not as Strasburgher supposed to excessive mutation, nor to an absence of one sex in the seed, as suggested by Hoffmann, nor to hybridisation as Jeffrey believed. P. F. F.

Seedling Structure.

Compton, R. H. An investigation of the Seeding Structure in the Leguminoseæ. *Jour. Linn. Soc.* (*Botany XLI No. 279, pp. 1—129* (*June 1919.*)

A description with illustrative figures is given of the distribution of the xylem and phloem in seedings of species taken from all sections of the order. It would be impossible in a brief note such as this to summarise or even indicate the facts and ideas which the author gives ; but it is clear that there is considerable variation in the amount and arrangement of the xylem elements in the root from a solid tetrarc core, to a ring of eight separate Y-shaped masses (as seen in section.) Those interested would do well to read the paper. But two conclusions may be given here—one that the size of the seeds is correlated with the habit of the plant, trees having much heavier seeds than herbs or shrubs ; the other that as with Angiosperues in general the tree habit is primitive, the herbaceous derived. As to whether the epigeal or the hypogeal mode of germination is the more primitive it is impossible to say. Both occur sometimes in the same genus, and the change from one to the other has probably occurred repeatedly in the evolution of the order. P. F. F.

Pollination Mechanisms.

Wyley, R. B. The Pollination of Vallisneria spiralis. *Bot. Gaz. LXIII, pp. 135—145.*

The mechanism of pollination in the American plant differs markedly from that described by Koerner, and widely copied from his *Pflanzenleben.* The chief points are that the staminate flowers float on their recurved sepals, till

carried by the wind they are caught in the cup of depression formed in the surface film round a female flower. A very large number may be so caught. When by the action of waves the female flower is drawn down slightly the staminate flowers are forced against it, standing vertically to the (inclined) walls of the depression, and if the female flower is temporarily drawn under the surface, several male flowers are carried down with a bubble of air. They are then completely turned over the stigmas, and so pollinate them. Each male flower produces about 100 grains of pollen, and since 400 ovules may be fertilised in the ovary as much as the whole pollen of several flowers must adhere to the stigmas. The author suggests that possibly his plant and Kœrner's are not of the same species. The paper is illustrated with photographs, and is a useful re-investigation of a process, hitherto thought to be sufficiently explained. The author would like photographs and drawings of the process in other countries. Since the plant is common enough in Indian pools of water perhaps some one reading this will take the matter up. P. F. F.

Physiology.

J. Loeb *in Bot. Gaz. for January, LXVIII, pp. 25—50,* continues his account of experiments on apogeotropism and the formation of roots in stems of *Bryophyllum.*

In this paper he examines the influence of leaves on the curvature of a horizontally placed stem. The stems were suspended over water in a closed jar. Very striking differences were shown in the rate and amount of geotropic curvature according to the position of the leaf, if only one is left on the stem. If the leaf is at the apical end curvature and root-formation are both much greater than when a basal leaf only is left. Curvature is due to a growth of the cortex, which is naturally in a state of tension. So that when the cortex is removed from the lower side the curvature is very slight, but if removed from the upper side it is very great. He finds that conditions which favour root-formation (*e.g.*, a leaf left at the apical end) favour also curvature, while those, which favour shoot-formation (*e.g.*, a leaf left at the basal end) do not. He suggests therefore that each leaf has a tendency to send shoot-forming substances towards the apex, and root-forming substances towards the base of the stem; and that probably geotropic curvature is due to a specific substance (hormone) which is associated with or identical with the root-forming hormone, and that these hormones have a tendency to collect in the cortex of the lower side of a horizontal stem. The common phenomenon of a lateral branch taking the place of a decapitated stem by growing erect, (which he refers to as if only in certain Firs) would then be explained by the flowing of the shoot-forming hormonies into a lateral branch near the (decapitated) apex. "After this the mechanical advantage due to the vertical position will favour the continued flow of these substances in this branch, which thus becomes the new apex". The theory is an interesting one and falls into line with Sach's theory of special root-forming substances. It would be of value to have experiments on these lines with plants of other genera. P. F. F.

Plant Breeding.

Parnell, F. R.; Rangasawmi, G. N.; and Ramiah, K. The Inheritance Characters of Rice. *Mem. Agri. Dept. India. Bot. Ser. IX 2.*

The authors find the simple ratio of 1 to 3 in several varietal characters of the grains and of the stem and leaves of paddy, *e.g.*, long outer glumes in place of the usual very short ones; a piebald arrangement of the dark colour of the furrows of the grain, as contrasted with its even distribution; and similarly a piebald distribution of a golden colour of the inner glumes as contrasted with the full golden colour. This golden colour which appears as the grains ripen, in place of the more usual green ripening to a straw-colour is recessive to green. They find a purple pigmentation of various parts of the plant dominant over (the usual) green, the numbers of F_2 obtained being 41,121 to 13,664 or very nearly 3 to 1. But since in some crossings a ratio of 9 to 7 is obtained the colour is without doubt, they say, due to the simultaneous presence of two factors, one of which occurred in *both* of the varieties giving the first set of numbers in the ratio 3 to 1 in F_2; while the varieties of the other set giving 9 to 7 were heterozygous to both. This fact was proved by the production of purple pigment in a cross between two pure strains both of which were green. A dark colouring of the pulvinus and auricle is similarly dominant over green. Other segregating characters are a purple striation of the internode, purple glumes, purple stigma and purple axil. Among these last they find 'coupling' occurred; *viz.*, purple striation with purple glumes, and purple stigma with purple axil; while green internodes and glumes are associated with purple stigma and axil, showing a repulsion which proved to be between purple stigma and both purple striation and purple glumes. Though 60,000 plants were examined for this, no example of incomplete repulsion was recorded.

Another varietal character examined was a black colour of the inner glumes, which fades to a smoky colour when the grain is quite ripe. This colour is, as in so many cases, due to the combination of two factors. They find partial repulsion between both of these factors and that of purple striation of the internode.

Coming to the grain itself, inside the glumes, the red colour of some varieties was found to show the simple ratio of 3 : 1, indicating dominance over its absence: but in two natural crosses with red rice some of the F_2 plants had a grey-brown colour. Though the experiments at the time of publication were not complete enough to prove it, the authors think that this red colour is also due to the simultaneous presence of two factors.

P. F. F.

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Note to Contributors

It would greatly reduce the work of the Honorary Editor if the following rules are kept in mind by contributors :—

All matter for the printer should be typed and on one side of the paper only. The name of a genus should begin with a capital letter, but that of the species only when it is adapted from a proper name (Vienna Rules). No comma should be put in after the specific name and before that of the founder of the species. The Editor will see to the type but the writer may, if the likes, indicate it on the following lines. The name of a plant at the opening of a paragraph or when it is desired to direct special emphasis to it may be underlined wavy (~~~~~~~~~~) for printing in **antique** type, with the founder's initial or name underlined plain (_____) for *italics*; thus **Acalypha indica** *L.* If in the middle of a paragraph the name should be underlined plain, but the founder's initial not, thus *Acalypha indica* Linn.

Abstracts of papers in other Journals should begin with the author's name and initial, followed by the title of his paper and where it is published: the abstract itself beginning a new line. (See the abstracts in this number).

A reasonable number of reprints of original papers will be supplied if asked for at the time the contribution is sent in, by indicating the number required on the copy itself.

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Presidency College, Madras



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Intending Contributors are requested to see the note on page 3 of this cover.

THE

THE BAOBAB, TEYNAMPET,
MADRAS,
October 15, 1919.

DEAR SIR,

I am sending a copy of the second number of a new botanical journal which has been founded under the name of the " Journal of Indian Botany " for the publication of original papers in Botany which would not naturally find a place in the existing Indian Journals. For there is no other journal in India which could accept a paper on Ecology, Physiology, Histology, or the Cryptogams, except such as might be of agricultural interest. Yet India is so large a country, has so rich a flora, and so varied a climate, that there are here ample possibilities of work, the results of which might prove of value to botanists in almost every part of the world.

The number now sent is only the second: the third will be out next month, and it is intended to publish ten numbers annually. One can hardly doubt that the Journal will, as it becomes better known, contain more papers and increase in importance.

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THE
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VOL. I. OCTOBER, 1919. No. 2.

THE PHYSIOLOGICAL ANATOMY OF THE PLANTS OF THE INDIAN DESERT

BY

T. A. SABNIS, B.A., B.Sc.

St. Xavier's College, Bombay.

PREFACE.

I had the opportunity of visiting a portion of the great Indian Desert, in the company of Fr. Blatter and Prof. Hallberg, in the months of October and November 1917. The year was remarkable for its abnormal rainfall of over 40 inches as against the average of 10—13 inches; and the herbaceous flora had survived till the time of our visit. On seeing the plants from the different habitats of the Desert identified by Fr. Blatter and Prof. Hallberg, it occurred to me that a treatise on the physiological anatomy of the Indian Desert plants would not be out of place. For while much has been written on other desert floras, nothing has been done in that line of any Indian desert flora.

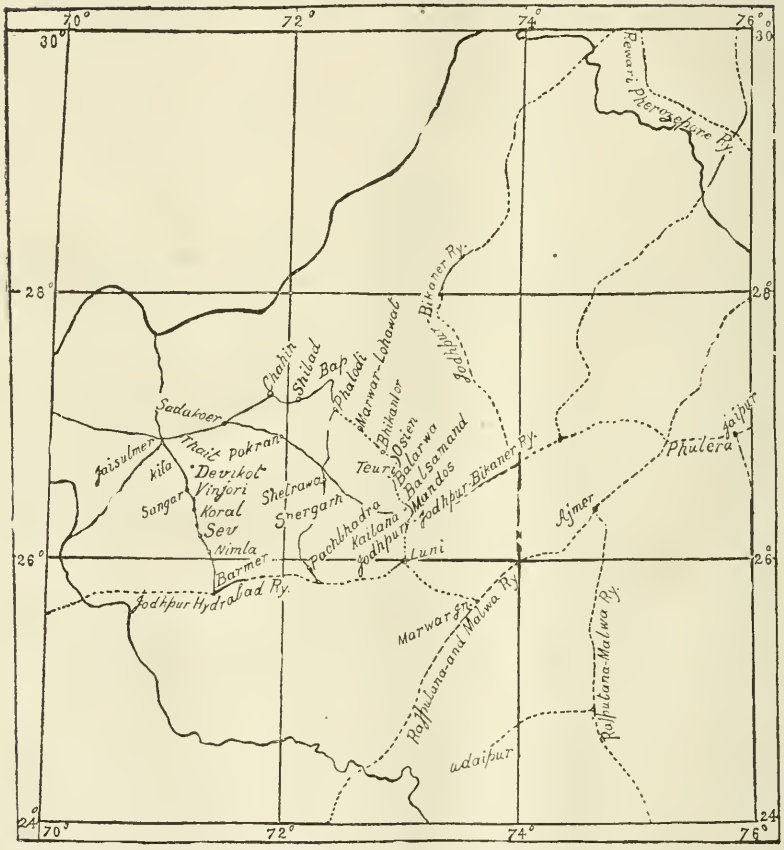
I set to work, with the view to carrying out my idea and the following treatise, in which I have confined myself to that portion of the Indian Desert which is marked in the map, is the result of my investigations.

I have taken considerable care to provide accurate sketches of the transverse sections of the leaves and the axes, as it is generally found that accurate figures give a clearer idea than long explanatory notes. The drawings have been made with the aid of Abbé's Camera Lucida; and the different powers of the oculars and objectives have been noted. I have used a Zeiss's microscope and generally Zeiss's apochromatic objectives and compensating oculars.

I hope the essay will prove an addition to our knowledge of the Desert Flora in particular and of the comparative anatomy and physiology of plants in general.

I must use this opportunity to thank Mr. M. V. Unakar, Acting Director of the Bombay and Alibag Observatories for the meteorological data of the Indian Desert.

THE RÁJPUTÁNA AGENCY



Scale: 1 Inch = 32 Miles or 2,027,520

INTRODUCTION.

To one who has the opportunity of visiting the Desert, the flora will at once appear striking and in many respects different from that inhabiting other more favoured provinces. The general barrenness of the country, the dry practically rainless climate and the scorching heat of the sun, not to omit the general susceptibility to the wind, have so modified the external organs of the desert plants, that it is but natural to conclude that the internal structure and the processes that are going on in the plants must in like way have been acted upon by these external factors.

Physical Aspects of the Indian Desert.

Some information about the topography, geology and the meteorological data of the area under consideration will elucidate the remark.

(*a*) *Topography.*—The portion of the Great Indian Desert, under consideration, is included in the two states Jodhpur and Jaisalmer and forms a square having the four towns Jodhpur, Bap, Jaisalmer and Balmer at its four angles. The general aspect is that of a succession of dry undulating plains and rolling sand-dunes of all sizes and shapes varying from 2 to 3 miles in length and 20 to 400 ft. in height. It is sparingly dotted with low bushes and isolated tufts of curious-looking plants, relieved here and there by green succulents and candelabra-like Euphorbias. Shifting sands are common and continually changing in size and shape. Villages are few and far between and consist of a few huts located round a well or a tank.

(*b*) *Geology.*—The region under survey is covered for the most part with wind-blown sand-dunes which are of the transverse type, *i.e.*, have their longer axes at right angles to the direction of the prevailing winds. From beneath these, rocks of earlier age crop out as isolated hills. Near Jodhpur the oldest rocks are schists belonging to the Aravalli system. These are overlain by rocks of volcanic origin, the Mallani series, with conglomerate at the base. Upon these, rest sand-stones of the Vindhyan age. At Balmer the rocks consist of sand-stones, grits and conglomerates containing ill-defined fossil remains. At Jaisalmer sand-stones and lime-stones of Jurassic age occur and Nummulitic rocks are common.

(*c*) *Meteorological data.*—It should be noted that the year 1917, the year of the tour, was remarkable on account of the abnormal amount of rainfall. The data of the normal maximum and minimum temperature, relative humidity of the air, rain-fall and number of rainy days are obtained by averaging the observations of 14 years (pp. 36 & 37).

(*d*) *General plan.*—As regards the general plan and arrangement of the subject the orders have been described in the sequence of

METEOROLOGICAL DATA :—

Stations.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
(1) Normals : Maximum Temperature.													
Jodhpur ...	76.1°	80.0°	91.1°	100.7°	106.5°	104.6°	97.7°	93.3°	94.9°	96.9°	89.7°	79.7°	92.6°
Pachbhadra ...	78.4	83.2	94.6	106.3	107.8	105.7	97 7	94.8	97.2	98.7	90.7	81.5	94.7
(2) Normals : Minimum Temperature.													
Jodhpur ...	49.6°	53.0°	62.9°	72.6°	80.2°	82.7°	80.5°	78.0°	75.5°	67.5°	58.5°	52.7°	67.8°
Pachbhadra ...	45.1	48.9	58 3	69.6	77.5	81.1	79.7	77.3	75.2	64.9	54.1	46.3	64.9
(3) Normals : Relative Humidity of the Air.													
Jodhpur ...	%	%	%	%	%	%	%	%	%	%	%	%	%
Pachbhadra ...	46.1	33.1	33.7	34.3	42.7	52.4	66.8	70.1	64.5	46.2	38.1	42.9	48.1
(4) Normals Rain-fall.													
Jaisalmer ...	0.21"	0.20"	0.20"	0.13"	0.22"	0.69"	2.17"	2.28"	0.83"	0.01"	0.04"	0.07"	7.00"
Balmer ...	0.11	0.14	0.07	0.05	0.32	1.22	3.51	3.13	1.52	0.02	0.08	0.05	10.22
Pachbhadra ...	0.26	0.15	0.10	0.08	0.51	1.28	3.64	3.71	2.02	0.05	0.06	0.10	11.96
Jodhpur (Obs.) ...	0.17	0.22	0.06	0.14	0.25	1.23	4.21	4.31	2.40	0.11	0.10	0.14	13.34
Phalodi ...	0.15	0.23	0.13	0.08	0.21	1.06	3.04	3.16	0.78	0.00	0.02	0.09	8.95

Not available.

(5) Normals : Number of Rainy Days.

Jaisalmer	...	0.6	0.7	0.4	0.6	0.6	1.3	3.7	3.7	3.4	0.0	0.1	0.2	13.0
Balmer	...	0.5	0.3	0.2	0.2	0.5	1.8	4.3	4 0	2·3	0.1	0.2	0.2	14.6
Pachbhadra	...	0.7	0.5	0.3	0.3	0.9	2.1	5.2	4 9	2.4	0.2	0.2	0.3	18.0
Jodhpur (Obs.)	...	0.5	0.6	0.2	0.5	0.7	1,9	5.0	5.7	2.5	0.2	0.2	0.5	18-5
Phalodi	...	0.7	0.5	0,4	0.1	0.5	1.7	3.7	4.4	1.2	0.0	0 0	0.2	13.4

(6) Actual Rain fall for 1917.

Jaisalmer	...	0.00	0.00	0.00	1.33	1.73	2.17	0.60	8.44	7.73	0 62	0.00	0.02	22.64
Balmer	..	0.00	0,00	0.30	0.20	1.24	1 64	7.01	6.21	4.20	2.70	0.00	0.00	23.50
Pachbhadra	...	0.00	0.00	0.00	0.10	3.07	6.50	8.08	5.19	3.88	5.00	0.00	0.00	31.82
Jodhpur (Obs.)	...	0.04	0.20	0.10	1.12	4.15	4.75	5.78	14.20	5.74	6.02	0.00	0,25	42.35
Phalodi	...	0.00	0 00	0.00	1.79	2.41	1.74	0.30	10.24	6.50	2.70	0.00	0,00	25.68

(7) Number of Rainy Days 1917.

Jaisalmer	...	0	0	0	3	3	2	3	13	9	1	0	0	34
Balmer	...	0	0	1	1	2	3	3	10	7	2	0	0	29
Pachbhadra	...	0	0	0	1	5	5	4	4	6	1	0	0	26
Jodhpur (Obs.)	..	0	1	1	4	6	2	5	10	14	3	0	1	47
Phalodi	...	0	0	0	4	4	4	1	14	8	1	0	0	36

Bentham and Hooker's system of classification. I have chosen the representative plants from the different parts of the desert and have examined fifty orders, 125 genera and 165 species. In dealing with the individual order, I have described the specific characters, the structure of the leaf and the structure of the axis and when necessary I have appended a general review of the order. I have omitted the structure of the root, as generally it is not available in herbarium specimens. The specific characters that are considered, are just those that will be useful in the diagnosis of the species. The different structures are considered in detail under the heads of "The structure of the leaf" and "The structure of the axis". The characters which are common to both the leaf and axis are usually dealt with jointly under the structure of the leaf as they are more prominent in the leaf.

I have embodied the interpretations of the various modifications of the different tissues in the descriptions of the structures of the leaf and the axis, and in the general review of the order, so that the descriptions can be said to contain at once an account of the anatomy and physiology of the plants in question. The concluding remarks at the end of the principal part of the work serve as a concise and complete summary of the treatise.

(*e*) *Method.*—As regards the method employed in preparing the herbarium material for the section work, small pieces of the leaves and the axes were soaked in water for about two hours and then hardened in formalin alcohol for about a day. The sections which were cut in 90% alcohol were placed, before mounting in glycerine, in a few drops of lactic acid on a slide and slightly warmed over a burner, so that the cells of the different tissues might expand to their proper dimensions.

(*f*) *A suggestion.*—The idea of employing micro-anatomical and micro-chemical characters for systematic purposes originated in times as early as those of Linnœus, and has been repeatedly put forward by several botanists, Radlakofer being considered as the founder of the anatomical method. It would be presumptuous on my part to discuss the merits of the method for systematic purposes; but from what little I have observed in my study of the physiological anatomy of the desert flora, I have grounds for believing that the study of Systematic Botany would considerably progress were more attention paid to anatomical characters than has heretofore been done. The method is no doubt laborious and a systematic botanist would be loth to adopt it, owing to the huge amount of the material submitted to him for identification from all sides. I admit this difficulty and suggest that the anatomical characters should be used at least as confirmatory evidence in establishing genera and species.

MENISPERMACEAE.

Cocculus cebatha *DC.*—*Figs.* 1, 2. (p. 39)—Epidermis of the leaf composed of thin-walled tabular cells. Stomata occurring on both the surfaces. Subsidiary cells accompanying the guard-cells. Mesophyll composed wholly of palisade cells. Internal glands absent. Pith cells containing clusters of acicular crystals of oxalate of lime. Clothing hairs bicellular and curved. Glandular hairs absent. Veins embedded and enclosed in green sheaths. Axis slightly ribbed, ribs strengthened by a few sclerenchymatous fibres. Epidermal cells of the axis tabular with outer walls greatly thickened and cuticularised. Cortex formed of chlorophyll containing parenchyma. Pericycle composed of large groups of stone-cells. Wood formed of xylem bundles separated by broad medullary rays extending to the cortical chlorenchyma. Groups of cells resembling bast fibres on the inner face of the xylem bundles. Pith composed of thick-walled cells.

Structure of the leaf

Epidermis is composed of tabular cells, with outer walls flat and a little thickened. Lateral and inner walls are thin and the former are straight. Stomata are accompanied by subsidiary cells and are more numerous on the under-surface. Guard-cells are situated on a level with the surrounding cells, with the front cavity slightly depressed, or on a level with the surface, fig 1. The mesophyll is composed of a homogeneous tissue of short palisade cells. Internal glands are absent in the leaf as well as in the stem. Oxalate of lime is not found in any form in the leaf.

Veins are embedded and are enclosed in green bundle sheaths. Veins of the mid-rib, which is prominent above and below, are vertically transcurrant above and below by collenchyma; the bundles are protected on the lower side by small groups of stone-cells.

Hairy covering on the leaf and axis consists of clothing hairs. Clothing hairs are made up of a short thin-walled basal cell and of a long curved thin-walled pointed terminal cell.

Structure of the axis

Epidermal cells are small and tabular with outer walls very greatly thickened and cuticularised. Lateral and inner walls are thin and the former are straight. The axis is slightly ribbed, the ribs being strengthened by a few sclerenchymatous fibres.

The cortex is formed of chlorophyll containing parenchyma which extends to the medullary rays between the groups of stone-cells of the

sclerenchymatous pericycle. The pericycle consist of large groups of stone-cells separated by the chlorophyll containing parenchyma of the cortex. The wood (fig. 2) is composed of large xylem bundles separated by broad medullary rays which come into contact with the chlorophyll containing parenchyma of the cortex. Vessels are large and have simple perforations. Groups of cells, resembling bast fibres, are present on the inner side of the xylem. Inter fascicular wood-prosenchyma is not developed. The endodermis is not differentiated. The soft bast occurs in groups on the outer side of the xylem, separated by medullary rays. The pith is composed of thick-walled cells and some of these contain small clusters of acicular crystals of oxalate of lime.

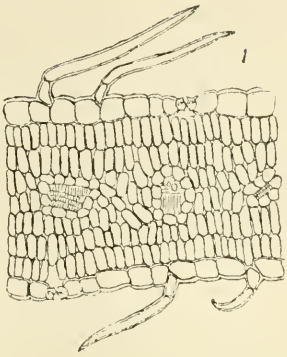
Woody.—The middle tissue of the mesophyll composed of large colourless polygonal cells with water-storage function. Neither surface of the leaf grooved. Axis not furrowed. Assimilatory tissue of the axis composed of short palisade cells. Sclerenchymatous pericycle in the form of a few scattered bast fibres. Vascular ring broad with vessels uniformly distributed in incomplete rows and more numerous in the lower half.

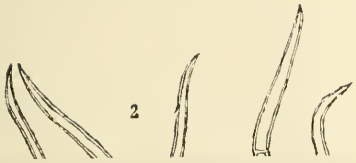
Farsetia macrantha *Blatt and Hall., Figs.* 4, 7, 8. Herbaceous.—Middle tissue of the mesophyll composed of chlorophyll containing horizontally elongated cells with assimilatory function. Lower surface of the leaf characterised by ridges and furrows. Axis furrowed. Assimilatory tissue of the axis formed of an outer portion of palisade cells and of an inner portion of chlorenchyma. Sclerenchymatous pericycle in the form of closely placed large groups of bast fibres. Vascular ring undulate and composed of small vascular bundles connected by narrow strands of interfascicular wood prosenchyma with cells resembling stone cells.

Structure of the Leaf.

Epidermis consists of horizontally tabular cells with outer walls greatly thickened and arched convexly outwards. Lateral walls are undulate. Stomata occur on both the surfaces and are accompanied by subsidiary cells one of which is smaller than the other two. The front cavity is placed in a depression formed by outer thickened walls of the epidermal cells. Guard cells are placed in the plane of the surrounding cells. (Fig. 5.) Stomata on the axis are numerous and have the same characters as those on the leaf. Mesophyll is isobilateral, and is characterised by a middle tissue which is composed of large thin-walled colourless polygonal cells, perhaps acting as water reservoirs in *F. jacquemontii* (Fig. 3) and of horizontally elongated green cells in *F. macrantha* (Fig. 7.) Internal secretary organs





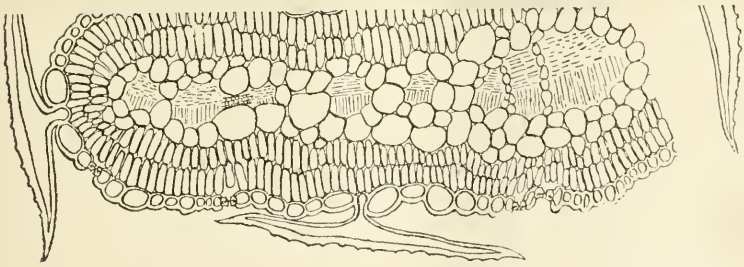


To be inserted in the Journal of Indian Botany Vol. I No. 2 to face page 40.

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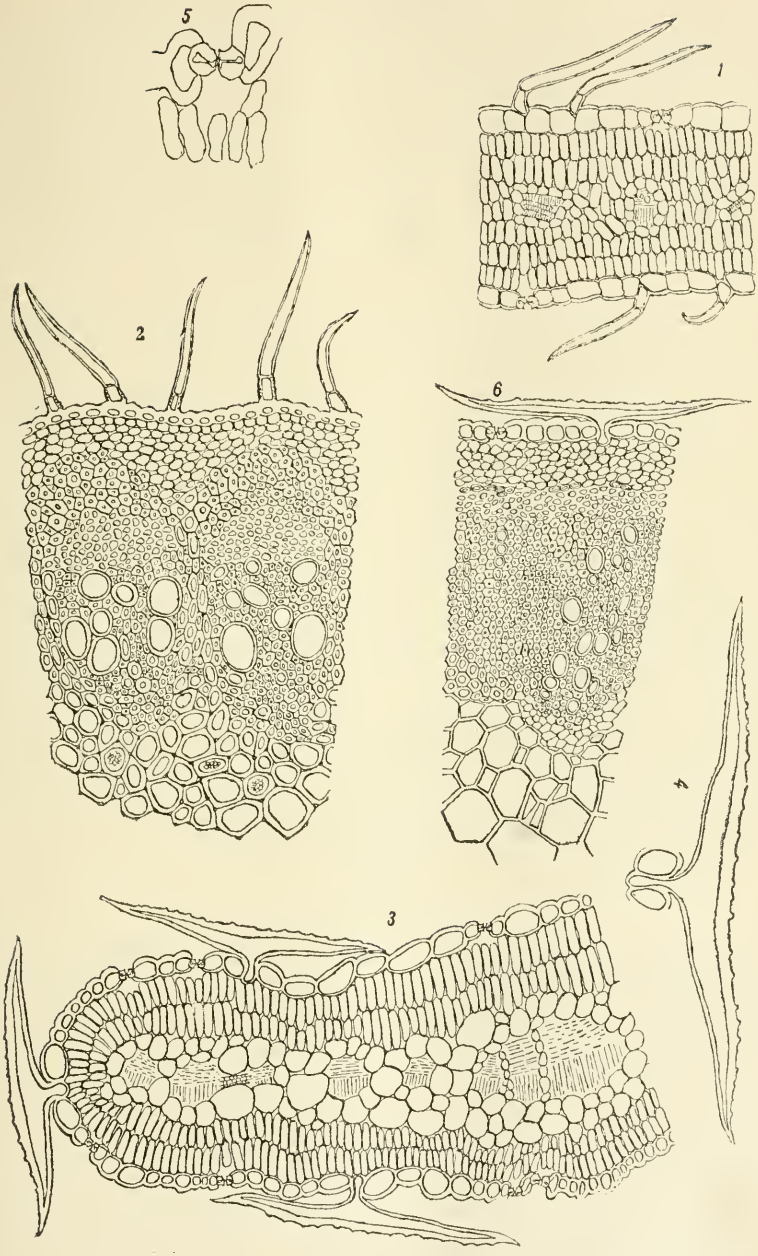
CRUCIFERAE.

Farsetia jacquemontii *Hook., Figs.* 3, 4, 5, 6.



sclerenchymatous pericycle. The pericycle consist of large groups of stone-cells separated by the chlorophyll containing parenchyma of the cortex. The wood (fig. 2) is composed of large xylem bundles separated by broad medullary rays which come into contact with the chlorophyll containing parenchyma of the cortex. Vessels are large and have simple perforations. Groups of cells, resembling bast fibres, are present on the inner side of the xylem. Inter fascicular wood-prosenchyma is not developed. The endodermis is not differentiated. The soft bast occurs in groups on the outer side of the xylem, separated by medullary rays. The pith is composed of thick-walled cells and some of these contain small clusters of acicular crystals of oxalate

Epidermis consists of horizontally tabular cells with outer walls greatly thickened and arched convexly outwards. Lateral walls are undulate. Stomata occur on both the surfaces and are accompanied by subsidiary cells one of which is smaller than the other two. The front cavity is placed in a depression formed by outer thickened walls of the epidermal cells. Guard cells are placed in the plane of the surrounding cells. (Fig. 5.) Stomata on the axis are numerous and have the same characters as those on the leaf. Mesophyll is isobilateral, and is characterised by a middle tissue which is composed of large thin-walled colourless polygonal cells, perhaps acting as water reservoirs in *F. jacquemontii* (Fig. 3) and of horizontally elongated green cells in *F. macrantha* (Fig. 7.) Internal secretary organs


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are not found in either of the species. Veins are embedded and are provided with sheaths of thickened green cells. The bundles are accompanied by arcs of collenchyma on the lower side, protecting the phloem of the veins. Hairy covering on the leaf and axis consists of densely placed clothing hairs. The hairs are unicellular, two-armed with their thin walls bearing knobs incurstated with carbonate of lime, fig. 4. The hairs are appressed, filled with air and white; and protect the plants from insolation by reflecting the rays of light. Clandular hairs do not occur in either of the species.

Structure of the axis.

Epidermis is composed mostly of vertically tabular cells with outer and inner walls greatly thickened and-cuticluarised, much more so in F. macrantha. Lateral walls are thin and undulate.

Primary cortex is characterised by assimilatory tissue composed of short palisade cells in *F. jacquemontii* (fig. 6) and of palisade tissue on the outer side and chlorencyma on the inner side in *F. macrantha* (fig. 8). Sclerencymatous pericycle is represented in *F. jacquemontil* (fig. 6) by a few scattered bast fibres, and in *F. macrantha* by numerous closely placed groups of bast fibres, (fig. 8.) The wood in *F. jacquemontii* (fig. 6) is quite composite and has vessels uniformly distributed in incomplete rows, the vessels being more numerous and larger in the lower half. In *F. macrantha* (fig. 8) the vascular ring is undulate and is composed of very small xylem bundles connected by narrow strands of interfascicular wood prosenchyma formed of thick walled cells having small lumina. There are large groups of wood parenchyma enclosing the lower portions of the xylem bundles. Medullary rays do not occur in either of the species.

The pith is composed of thin-walled cells.

Capparidaceae.

Cleome papillosa *Steud.* Figs. 10, 11, 12, 17, 18. Herbaceous. Epidermal cells with outer walls strongly papillose. Guard cells in the plane of the surrounding cells. Mesophyll composed of palisade tissue on the adaxial side and of arm-palisade tissue on the abaxial side. Veins not provided with bundle sheaths. Internal glands absent. Glandular hairs multicellular and capitate. Outer walls of the epidermal cells of the axis superficially granulated. Assimilatory tissue in the axis formed of chlorophyll containing parenchyma. Pericycle consisting of long, thin groups of stone cells. Wood composite. Soft bast occuring in groups. Pith formed of thick-walled cells.

(*To be continued.*)

To be inserted in the Journal of Indian Botany Vol. I No. 2 to face page 43.

Abbreviations used in the explanation of the plates.

Oc.—ocular.
Com.—compens ocular.
Ob.—objective.
Ap.—apochromatic.
T.S.—transverse section.
A—water-storing cell.
G.—internal gland cell.
L.C.—lysigenous cavities.
G.C.—secretory cavities.
Cl.—collenchyma.

Plate I.

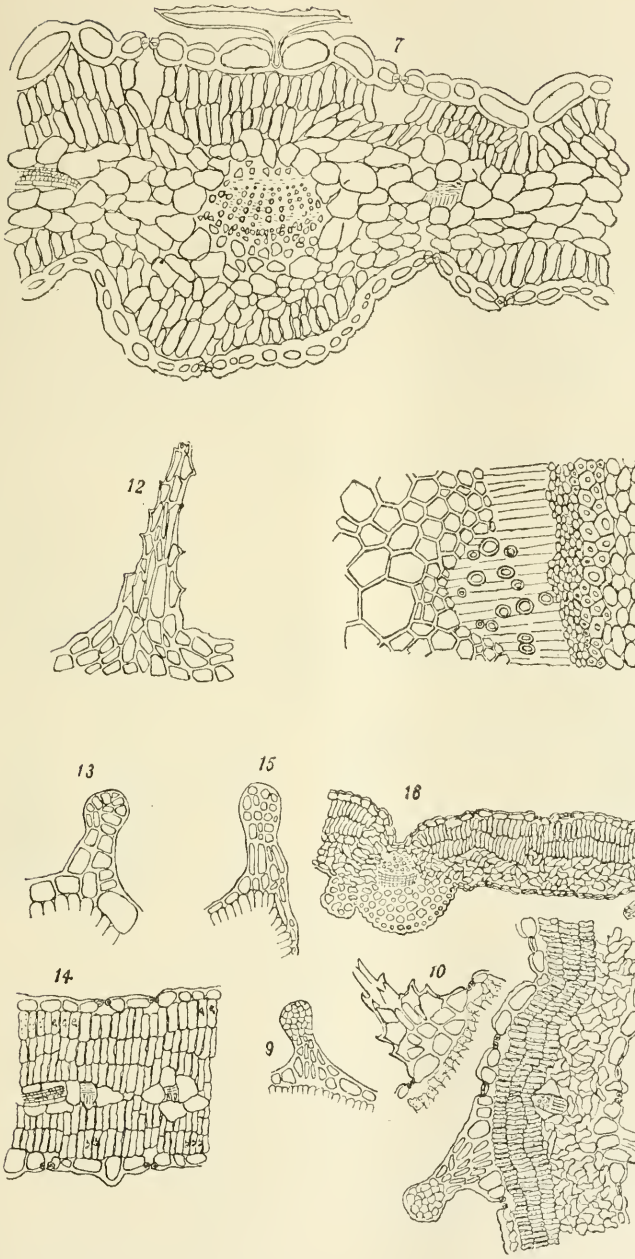
1-2. *Cocculus Cebatha.*
1 T.S. of the leaf.
Oc. 6 Com.; Ob. 8 mm. Ap.
2 T.S. of the axis.
Oc. 8 Com.; Ob. 8 mm. Ap.
3-6. *Farsetia Jacquemontii.*
T.S. of the leaf.
Oc. 3 Com.; Ob. 3 mm. Ap.
4 Hair on the axis.
Oc. 2 Com.; Ob. 3 mm. Ap.
5 Stoma on the leaf.
Oc. 6 Com.; Ob. 3 mm. Ap.
6 T.S. of the axis.
Oc. 2 Com.; Ob. 3 mm. Ap.

N.B.—To get the original dimensions multiply by 1·7.

Plate II.

7-8 *Farsetia Jacquemontii.*
7 T.S. of the leaf.
Oc. 2 Com.; Ob. 3 mm. Ap.
8 T.S. of the axis.
Oc. 2 Com.; Ob. 3 mm. Ap.
9-12 *Cleome papillosa.*
9 Glandular hair on the leaf.
Oc. 1; Ob. C.
10 Glandular hair on the leaf.
Oc. 1; Ob. C.
11 T.S. of the leaf.
Oc. 2; Ob. C.
12 Hair on the axis.
Oc. 1; Ob. C.
13-14 *Cleome brachycarpa.*
13 Glandular hair on the leaf.
Oc. 1; Ob. 7.
14 T.S. of the leaf.
Oc. 2; Ob. C.
15-16 *Cleome viscosa.*
15 Glandular hair on the leaf.
Oc. 3; Ob. C.
16 T.S. of the leaf.
Oc. 2; Ob. C.

N.B.—To get the original dimensions multiply by 1·7.


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11

A NOTE ON CERTAIN SPECIES OF POLYGALA

BY

K. RANGACHARIAR, M.A., AND C. TADULINGAM, F.L.S.

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During the month of December last year some species of Polygala came up in great profusion and they were unusually dominant on the Estate of the Agricultural College. They consisted of the four species dealt with in this note. Out of these four, only one, *Polygala chinensis* L. is included in Hooker's Flora of British India, and in Gamble's Madras Flora this species and *Polygala bolbothrix* Dunn are included. The other two species are merged under *Polygala erioptera*, DC. Prod. i. 326 and *Polygala chinensis* Linn., although they differ very much from these species. In Wight and Arnott's Prodromus 1.36, *Polygala Vahliana* DC. is treated as a distinct species.



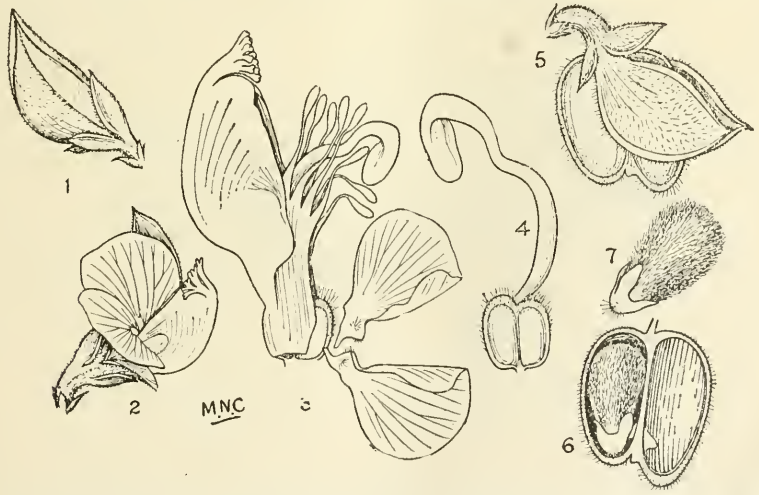
Text fig. 1. P.-Vahliana :—A. a branch, 1. flower-bud, 2. an open flower, 3. ovary, 4. corolla, 5. fruit, 6. fruit cut open, 7 seed.

1. **Polygala Vahliana** *DC. Prod. 326* :—This is a freely branching herb. Stems and branches are procumbent and pubescent. Leaves are oblong, narrowed downwards into a petiole, obtuse, mucronulate or not, softly hairy on both the surfaces and varying in length from 3/16 to 7/16 inch. Racemes are very short, opposite to the leaves or lateral, 3 to 6 flowered ; bracteoles are very small and persistent. The two inner larger sepals are somewhat membranous with a green midnerve, elliptic, villous and about as long as the fruit. The petals are pinkish and the keel is cristate. The capsule is very small, oval, emarginate, glabrous on the faces and softly villous at the edges only,

1/8 inch long and 1/16 inch broad. Seeds are narrow, strophiolate and without any appendages.

This plant matches very well with Wight's type specimen No. 131 in the Madras Herbarium named *Polygala Vahliana* DC. It is quite distinct from *Polygala erioptera*, *DC.* 1. 326. and differs from it in several points. *Polygala Vahliana*, DC. is a prostrate plant with oblong hairy leaves, and it has villous sepal wings and pinkish petals, whereas *Polygala erioptera* DC. is an erect one with stiff branches and almost glabrous linear leaves and has quite glabrous wing sepals and yellow petals. Specimens of this plant were sent to Mr. Gamble * and he now considers this to be a distinct variety of *Polygala erioptera*. The differences are, we think, quite sufficient to consider this as a distinct species, as is done by Wight and Arnott in their Prodromus.

2. Polygala sp:—This is an annual herb. Stems and branches are mostly procumbent and densely hairy. Leaves are either ovate-oblong, obtuse rarely retuse, or oblong-lanceolate to oblong-linear, acute, mucronulate, shortly petioled and with soft hairs scattered on both the surfaces. Racemes are shorter than the leaves, lateral, densely softly hairy with a few to many short pedicelled flowers closely set. The larger inner sepals are greenish with membranous margins, thinly hairy all over, obliquely ovate lanceolate, acuminate, about as long as or a little longer than the capsule. Petals are rose-purple. Capsule is oblong, longer than broad, about $\frac{1}{8}$ inch or a little longer, with unequal lobes, oblique and emarginate at the apex, margin ciliate. Seeds are oblong, with a three-fid strophiole without any wings or rarely two arms with very short obscure wings.



* Who is working on the new official "Flora of the Madras Presidency."



(B) P. arvensis willd. (C) P. bulbothrix Dunn I. (D) P. bulbothrix Dunn II.

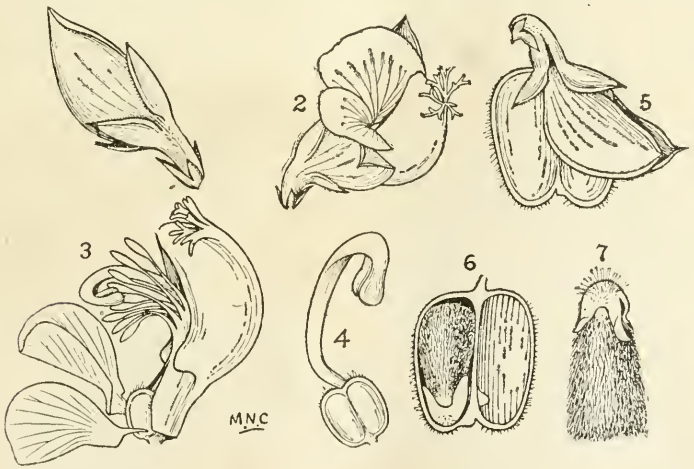
Text fig. 2. Fig. B. p. 46 a branch. Text Fig. 2. 1. flower-buds, 2. open flower, 3. petals and ovary, 4. ovary, 5. fruit, 6. fruit cut open, 7. seed.

This species is no doubt closely allied to *Polygala chinensis* L., but differs from it in the following respects. The stems and leaves are more pubescent than in *Polygala chinensis* L., the flowers are smaller than those of the other, rose-purple and not yellow, the wing sepals are pubescent and not glabrous, the capsules are oblong and longer than broad and not rounded and broader than long as in *Polygala chinensis* L., seeds are oblong and not broadly ovate oblong and plumpy, strophiole is without any wing or rarely with minute obscure wings on two of the arms, not with wings as in *Polygala chinensis* L.

These differences are sufficient to consider this a distinct species. As the name *Polygala arvensis* Willd. is a synonym of *Polygala chinensis* L., a new name should be given to this plant. Specimens of this plant are being sent to Mr. Gamble and to Kew, and after hearing from them this will be named.

This plant appears to be the one described by Wight and Arnott in their Prodromus as *Polygala arvensis* Willd. *var.* γ. and it is figured in Rheede's Hort. Mal. Vol. 9 t. 61.

3. Polygala bolbothrix *Dunn.* This is a freely branching annual herb. Stems and branches are diffuse, prostrate and the whole plant is covered with scattered bulbous-based hairs. Leaves are linear-oblong to narrowly oblong linear, glabrous. obtuse, mucronate, varying in length from ½ to 1½ inches, margins with distant bulbous-based



cilia, especially so on the lower half. Racemes are extra axillary,

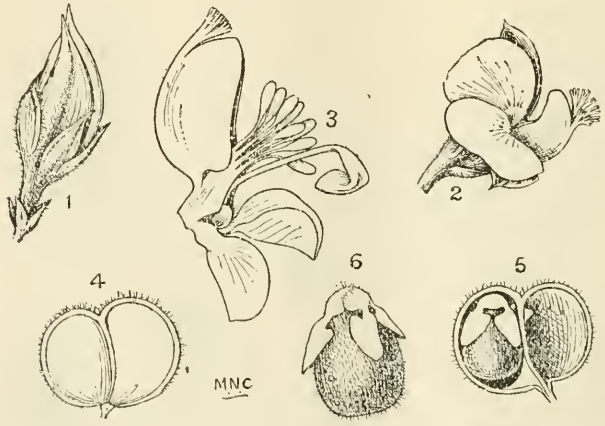
twice as long as the leaf or more when fully grown, and many flowered. The two inner large sepals (wings) are membranous-margined, ovate, acute, glabrous and slightly longer than the capsule. The capsule is small, slightly oblique, not margined, glabrous and rigidly ciliated on the margin and emarginate. Seeds are oblong and strophiolate without wings or sometimes the two arms with very obscure wings.

Fig. C., p. 46, 1. branch, 2. a bit of a leaf with cilia, 3. a bit of stem, (D) branch of the broad-leaved form. Text fig. 3. Parts of the flower. 1. flower-bud, 2. open flower, 3. petals, stamens and ovary, 4. ovary, 5. fruit, 6. fruit cut open, 7. seed.

This plant is described as *Polygala ciliata* (L) by Wight and Arnott in their Prodromus Vol. I p. 38, and it is renamed as *Polygala bolbothrix* by Mr. Dunn (vide Kew. Bulletin No. 3, 1916, p 63). The name *Polygala ciliata* (L) could not be retained as this was applied to a species of *Salomonia* by Linnaeus. Evidently the plant referred to by Wight and Arnott in their Prodromus cannot be *Polygala ciliata* L. and the synonym should be *Polygala ciliata* of W. & A. Prodromus i.38.

The form here described has long linear leaves and this was abundant here. The other form which is more common has ovate or obovate leaves.

4. Polygala chinensis *L.*—This can be distinguished from the others easily. The flowers of this species are yellow, the fruit is rounded, broader than long, the seeds are ovate oblong, plumpy and the strophiole is provided with well developed wings.



Text fig. 4.—1. flower-bud, 2. open flower, 3. petals and ovary, 4. fruit, 5 fruit cut open, 6. seed.

THE INDIAN SPECIES OF ERIOCAULON.

BY

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Presidency College, Madras.

The difficulty of identifying from published descriptions the species of ERIOCAULON found in South India led me finally to attempt a revision of the Indian species from material available in the herbaria of this country. A full account with photographs of the type or other sheet of most of the species will appear in the *Records of the Botanical Survey of India*, but as it seems probable that it will not be published for some considerable time, a short resume now may not be out of place, and may perhaps be of assistance to collectors of this difficult genus.

The genus was monographed in *Das Pflanzenreich* in 1903, by Ruhland, who separated and arranged the species according to the number of the parts in each whorl of the flower, to the geographical distribution (Old and New Worlds) and to minor characters of various kinds. Taking only the species which occur in India it appears to me that they fall naturally into eight groups, or sub-genera, in each of which a tendency to reduction of the floral parts continually shows itself, so that Ruhland's arrangement according to the number of the parts and the perfection of the flower cuts across the natural groupings. The arrangement in the *Flora of British India* follows in some respects more natural lines, but too much stress is laid in most of the descriptions on unimportant characters, and the possession by some species of white or yellow anthers, instead of the more usual black, is altogether ignored.

The least modified species appear to be glabrous plants with short discoid stem, narrow leaves, and peduncles bearing heads of male and female flowers, each subtended by a black slightly hairy floral bract; and having in the male three sepals combined into a spathe-like calyx split on the upper side, a funnel-shaped corolla with three equal lobes and six stamens with black anthers; and in the female three equal, boat-shaped sepals, three equal oblanceolate ciliate petals, a superior ovary with three one-seeded lobes, and a three-fid style. From this fairly primitive type development appears to have proceeded along several different lines to produce groups of species as follows:—

I. SIMPLICES. Land or water-plants with the characters given above. Some of the species have (*a*) glabrous, some (*b*) villous recep-

tacle. In both sub-groups reduction occurs in the female sepals, one of which may be reduced to a mere bristle or be absent altogether. This reduction, which is found also in other groups, is clearly correlated with the compression of the flowers in the head, for it is the medial, ad-axial, sepal which is reduced in each case.

To this group belong (*a*) *E. Geoffreyi* sp. nov. (fig. 2), *E. Collettii* Hook. f., *E. barba-caprae* sp. nov., *E. gregatum* Koern., *E. nepalense* Presc., *E. Pumilio* Hook. f., *E. truncatum* Ham., *E. Trimeni* Hook. f., and *E. Duthiei* Hook f.; (*b*) *E. xeranthemim* Mart., *E. luzulaefolium* Mart., *E. Thwaitesii* Koern., *E. achiton* Koern., *E. quinquangulare* L., *E. roseum* sp. nov., *E. trilobum* Ham., *E. collinum* Hook. f., *E. Dianæ* sp. nov., and *E. Sedgwickii* sp. nov.

II. SETACEUM. Submerged plants with elongate stems and linear leaves. The heads and flowers are small, but as in I. To this belong *E. setaceum* Linn. (not of F.B.I.) and *E. intermedium* Koern. (incl. E. setaceum of F. B. I.)

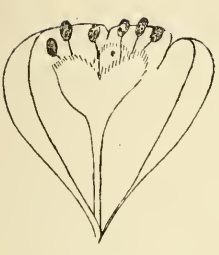
III. HIRSUTAE. Whole plant hairy, otherwise as in Ib. To this belong *E. Brownianum* Mart. (incl. *E. nilagirense* Steud.), *E. robustobrownianum* Ruhl, *E. gracile* Mart., *E. Rhodae* sp. nov., *E. Wightianum* Mart, (incl. E. *Helferi* Hook f.) and *E. lanceolatum* Miq.

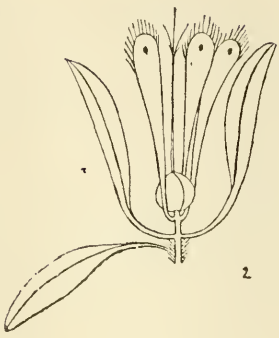
IV. ANISOPETALAE. One male petal much enlarged and projecting beyond so as to hide the floral bracts (fig. 4), otherwise as in Ib. To this belong *E. odoratum* Dalx., *E. longicuspis* Hook. f., (incl. *E. polycephalum* Hook. f.,) *E. atratum* Koern., *E. ceylanicum* Koern. (incl. *E. subcaulescens* Hook. f.), *E. caulescens* Steud. (incl. *E. robustum* Hook. f.) and *E. cristatum* Mart.

V. SCARIOSÆ. Involucral and floral bracts glabrous and scarious, otherwise as in Ib. To this belong *E. oryzetorum* Mart., *E. Hamiltonianum* Mart., and *E. Edwardii* sp. nov.

VI. CRISTATO-SEPALAE. Female sepals strongly boat shaped, and crested or swollen along the keeli; otherwise as in I. *E. Margaretae* sp. nov., *E. Eleanorae* sp. nov., *E. minutum* Hook. f., *E. stellulatum* Koern., *E. echinulatum* Mart., *E. cuspidatum* Dalz., *E. sexangulare* L. (incl. *E. longifolium* Nees.) and *E. Thomasi* sp. nov. The last three species having thick rather than crested keels should possibly be separated into another group, but only an examination of species of other countries could determine this. The group appears to have its centre in north South America. Considerable reduction in sepals and petals occurs (figs. 5, 6, 7).

VII. CONNATO-SEPALAE. The female sepals are connected into a spathe like calyx, like the male of other groups. *E. alpestre* Hook. f. (fig. 8). A small group apparently confined to China, Japan and the Tibetan Himalayas, and quite distinct from any other Indian species.

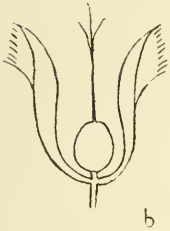

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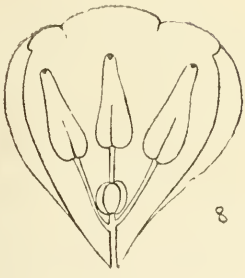

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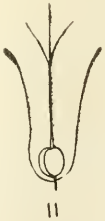

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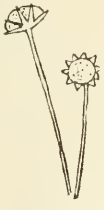

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VIII. LEUCANTHERAE. The anthers are white or yellow; otherwise as in Ib. Many are water plants, with linear leaves. The group should probably be considered as of equal rank to the rest of the groups taken together. To it belong *E. horsley-kundæ* sp. nov., *E. breviscapon* Koern., *E. rivulare* Dalz., *E. miserum* Koern., (incl *E. mitophyllum* Hook. f.), *E. fluvatile* Trimen., *E. Sieboldianum* Sieb. et Zucc. (Figs. 9, 10, 11.)

Many of the characters on which stress is laid in the published descriptions of species, such as the twisting of the scapes or the length of the pedicel, are either common to all species or dependant on age, and are therefore only an encumbrance to critical definition. Leaving these on one side and confining attention to the characters given above and their modifications, the species are found to be much more easily separable than has hitherto appeared. Following on this it is clear that some of the species have in the past been given far too wide a range of distribution, because of faulty identification and consequent confusion with other species. Thus *E. luzulaefolium* Mart., given in the F.B.I. and other works as occurring throughout India, is confined to the hilly tracts of Eastern Bengal and the Shan states; *E. quinquangulare* L belongs only to South India, and chiefly to the eastern side; and its place in Bengal is taken by *E. trilobum*, which does not occur in the Peninsula.

Several new species are described, but it is recognised that some at least of these may not be new, for I have failed to identify several described by Ruhland and others. Perhaps the strangest of the latter is *E. melaleucum* Mart., a species which occurs in the F.B.I. and in other floras but has no named representative in the Herbarium of the Royal Botanic Gardens, or in any other Indian Herbarium. Ruhland describes the anthers as white, and my E. Horsley-kundae (fig. 9) may therefore be it, but Martius' original description is not quite definite enough and those of subsequent writers point to the probability of it having been confused with other species.

An interesting evolutionary fact comes to light in the existence of parallel development in different strains. Thus a reduction of one female sepal from a boat-shaped to a flat scale occurs as *E. collinum* crosses from S. India to Ceylon; *E. trilobum* in Bengal differs from *E. quinquangulare* in S. India hardly at all, except in somewhat more pronounced a reduction; and both these have their counterparts in *E. Dianæ* (fig. 3) in the Bombay Presidency, where every stage of this reduction can be seen. Again a lengthening of the involucral bracts so that the head appears rayed occurs in Group I in *E. Dianæ*, in the stock of *E. quinquangulare* as var. *Martiana* (mihi) and as *E. roseum* mihi) (fig. 13) and in *E. xeranthemum*; in group III it occurs in var.

Kurzii of *E. gracile*, and in group V. in *E. Edwardii*. A reduction of the female petals till they are only as wide as the hairs which spring from the base and form with them a tuft or brush, occurs in group I. in *E. Thwaitesii*, and in group VI. in *E sexangulare* (see fig. 7). From the former species arose *E. achiton* with no petals at all. The submerged habit is correlated with filiform leaves in group I. in *E. gregatum* and *E. barba-caprae*, and in group VIII in a series beginning with *E. breviscapon* and ending with *E. fluvatile* ; while in group II it is accompanied by a great lengthening of the stem.

This work was only rendered possible by the kindness of the officers in charge of the herbaria in the Royal Botanic Gardens, Calcutta (which has most of the types) ; the Agricultural College, Coimbatore ; the College of Science, Poona ; the Forest College, Dehra Dunn ; and the Royal Botanic Gardens, Peradiniya, in placing their material at my disposal for examination, and to them my thanks are due and warmly tendered ; but particularly to Lt.-Col. A. T. Gage, the Director of the Botanical Survey of India, and Superintendent of the Royal Botanic Gardens, Calcutta whose collection is the largest and contains most ' types '.

Explanation of the Figures

Fig. 1. Male flower of *E. quinquangulare L.*
Fig. 2. Female flower of *E.* do. do.
Fig. 3. Do. do. *E. trilobum* Ham.
Fig. 4. Male do. *E. caulescens* Steud.
Fig. 5. Female do. *E. Eleanoræ* sp. nov.
Fig. 6. Do. do. *E. minutum* Hook
Fig. 7. Do. do. *E. Thomasi* sp. nov.
Fig. 8. Do. do. *E. alpestre* Hook. f.
Fig. 9. Male do. *E. horsley-kundæ* sp. nov.
Fig. 10. Do. do. *E. Sieboldianum* Sieb et Zucc.
Fig. 11. Female do. *E.* do. do.
Fig. 12. Head of ... *E. Dianæ* sp. nov.
Fig. 13. Do. ... *E. roseum* sp. nov.

CONTRIBUTIONS TOWARDS A FLORA OF BALUCHISTAN.

From materials supplied by Col. J. E. B. Hotson, I. A. R. O.

BY

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Ranunculaceae.

Clematis *L.*

Clematis orientalis *L. Sp. Pl. 765.* Loc.; Sitani, 28° 19′ N, 66° 5′E (no. 367, 367A), about 5,300 ft. 29-VI-18.

Adonis *L.*

Adonis aestivalis *L. Sp. Pl. 771.* Loc.: Panjgur, about 3,100 ft. (no. 155), Garmkan, about 6 miles NE of Panjgur, about 3,125 ft. (no. 155A). Fl. and fr. in March 1918. *Vern. Name*: Buchki (Bal. Brah. ?).

Ranunculus *L.*

Ranunculus aquatilis *L. Sp. Pl. 781* (partim) var. submersus *Gr. and Godr.* Loc.: Sitani, 28° 19′ N, 66° 5′ E, about 5,300 ft. (no. 365, and 365A), "at places the irrigation channels were starred with these flowers, like tiny water lilies." (Hotson). Fl. and fr. in June 1918.

Ranunculus muricatus *L. Sp. Pl. 780.* Loc.: Panjgur, about 3,100 ft. (no. M 154). Fl. and fr. in March 1918. *Vern. Name*: Kalafs (Bal.).

Ranunculus pseudo-muricatus *Blatt. and Hall. spec. nov.* Acaulis, humilis, glaber; folia omnia radicalia, longe-petiolata petiolo 20 mm longo, suborbiculata subreniformia, 13 mm diametro, breviter triloba lobis grosse obtuse-dentatis. Pedunculi foliis breviores, florigeri 10 mm, fructiferi vero 20 mm longi. Flores flavi; calyx patens sepalis ovatis acutis apice contortis (in herbario tantum?); petala late-oblonga, obtusa, sepalis brevioria. Carpella ca 7, rotundo-ovata; rostrum disco brevius, recurvum; margo rostrumque carpellorum viridia, sulcata; discus brunneus, punctulatus spinis ca 6 curvatis obsitus partem praesertim apicalem et ventralem occupantibus.—This species is distinguished from R. muricatus by being stemless and quite glabrous, by the patent calyx, by the shape and size of the petals, and by the sepals not being setulose. Loc.: Nag (W. Kolwa), about 83 miles E. by N. of Turbat, about 2,300 ft. (no. 154 A). Fl. and fr. in April 1918. *Vern. Name*: Kalafs (Bal.)

Ranunculus arvensis *L. Sp. Pl. 780.* Loc.: Khudabadan, ¼ mile N. of Panjgur, about 3,100 ft. (no. 182).Fl. in March 1918. *Vern. Name*: Zard Phul (Bal.).

Menispermaceae.

Cocculus *DC.*

Cocculus cebatha *DC. Syst. I (1818) 527.* Loc.: Kanoti, 47 miles N. of Las Bela, about 3,200 ft. (217A); W. side of Burida Pass, 140 miles SSW of Kalat, below 4,250 ft. (no. 217). "Every time I have seen this plant it has been growing out of a rock and hanging down the face of a cliff." (Hotson). 5-X-17 and 30-VIII-17. Uses: Is reputed to make water cold and to thicken it (Hotson). *Vern. Name*: Zamor (Bal., Br.).

Cocculus villosus *DC. Prodr. I. 98.* Loc.: Baran Lak, 28 miles S. of Wad, about 3,900 ft. (no. 380). Fl. in Oct. 1917.

Berberidaceae.

Berberis *L.*

Berberis lycium *Royle III 64.* Locality not given.

Berberis vulgaris *L. Sp. Pl. 472.* Loc.: Harboi, 18 miles ESE of Kalat, 9,000 ft. (21A,B,C). Fruit ripening about the time of the wheat harvest in the valleys, say June in these parts or early July. Uses: The small red berries are eaten by men and animals. The roots are boiled and give a decoction good for fever, especially high fever; it is said to make the chest "narm". (Hotson). *Vern. Name*: Zarch Brah.

Papaveraceae.

Hypecoum pendulum *L. Sp. Pl. 181.* Loc.: Khudabadan, ¼ mile N. of Panjgur, about 3,100 ft. (no. 191); Garmkan, 1 mile NE of Panjgur, about 3,125 ft. (no. 167). Fl. and fr. in March 1918.

Fumariaceae.

Fumaria *L.*

Fumaria parviflora *Lam. Encycl. II (1786) 567.* Loc.: Panjgur, about 3,100 ft. (no. M 173); Khudabadan, ¼ mile N of Panjgur, about 3,100 ft. (no. M 180); Fl. in March 1918—Fr. in March 1918. *Vern. Name*: Kankechk (Bal.), Kahurkah? (Bal.).

Cruciferae.

Arabis *L.*

Arabis sp. prope **A. tibeticam** *H. f. & T.* Loc.: Rakhshan river bed at Panjgur, about 3,100 ft. Fl. and fr. in March 1918 (no. 16).

Arabis sp. prope **A. purpuream** *Sibth. & Sm.*—Fructus immaturus. Loc.: Khudabodan, ¼ mile N. of Panchgur, about 3,100 ft. (no. 157 B). Fl. and fr. in March 1918. *Vern. Name*: Grabust (Br. and Bal.).

Barbarea *R.Br.*

Barbarea plantaginea *DC. Syst. II, 208.* Loc.: Rakhshan river bed at Panjgur, about 3,100 ft. (no. 160). Fr. in March 1918.

FARSETIA *Turra.*

Farsetia Jacquemonti *Hook. f. and T. in Proc. Linn. Soc. v. 148.* Loc. : Panjgur (no. M. 336). Fr. in May 1918.

Farsetia aegyptiaca *Turr. Diss. p. 1, tab. I.* Loc. : Garmkan, 1 mile NE of Panjgur, about 3,125 ft. (no. 165). Fl. and fr. in March 1918.

Farsetia sp. Fortassis specimen nanum *Farsetiae Hamiltonii* Royle.Loc. : Dokop 10½ miles E of Mand, about 650 ft. (no. 67). Fl. and fr. in March 1918.

Farsetia sp. Loc. : Manguli, 26° 45′ N, 65° 21′ E, about 2,600 ft. (no. 291). Fl. in April 1918.

Farsetia sp. Loc. : Kuldan (W. Kolwa), about 85 miles E. by N. of Turbat about 2,400 ft. (no. 244). Fl. just coming out in April 1918. *Vern. Name* : Alant (Bal.).

Farsetia sp. Loc. Nag (W. Kolwa), about 83 miles E. by N. of Turbat, about 2,300 ft. (no. 241). *Vern. Name* : Kular.

MALCOLMIA *R. Br.*

Malcolmia africana *R. Br. Kew. IV. 121.* Loc. : Not given.

Malcolmia Bungei *Boiss. Fl. Or. I. 226.* Loc. : Khudabadan, ¼ mile N. of Panjgur, about 3,100 ft. (no M 188). Fl. and fr. in March 1918. *Vern. Name* : Jadanik, Sochaku (Bal.).

GOLDBACHIA *DC.*

Goldbachia hispida *Blatt. & Hall. spec. nov.* Herba annua (?) glauca, 20 cm alta, a basi ramosissima, radice simplici, caule striato glabriusculo. Folia radicalia petiolata spathulata integra 4 cm longa, caulina oblanceolata—obtusa vel linearia obtusa basi breviter auriculata, margine remote et breviter hispido, costa media inferiore prominente. Flores racemos terminales ebracteatos, multiflores laxos formantes, minimi, (petalis roseis uti videtur) ; pedicelli ca 2 mm longi, floribus subaequilongi, filiformes, fructificantes incrassati reflexi 5 mm longi. Siliqua unilocularis indehiscens, monosperma 6 mm longa, vel disperma 9 mm longa, inter semina contracta, coriacea turgidal 2 mm lata basi attenuata, apice in stylum triangularem planum obtusum contracta, cujus margines decurrunt secus siliquæ latera ; facies siliquæ costa media plus minusve distincta ornatæ, interdum prominenter reticulatæ et bituberculatae si siliqua est monosperma, vel tetratuberculatae si siliqua est disperma ; tuberculis presentibus constrictio inter semina minus distincta. Semina anguste oblonga, subcylindrica, faciebus oppositis sulcata.—This species differs from Goldbachia laevigata in the following points : The margin of the leaves is hispid, the siliqua is sometimes 1-seeded, never 3-seeded, the siliqua shows distinct dimorphism. Note : As there is no doubt that this species belongs to the genus Goldachia, a slight change in De Candolle's diagnosis of the genus should be made. He says that there are 2 or 3 cells in the siliqua, superimposed in one row. According to the present knowledge of the genus we must say that there are 1-3 cells in the siliqua. Loc. : Harbud, about 55 miles E of Panjgur, about 3,700 ft. (no. 247 A). Fl. and fr. in April 1918. *Vern. Name* : Kularbahar (Bal.).

SISYMBRIUM *All.*

Sisymbrium Sophia *L. Sp. Pl. 922.* Loc.: Khudabadan, ¼ mile N. of Panjgur, about 3,100 feet (no. M. 181), Kalat, about 6,350 ft. (no. 395). Fl. and fr. in March 1918. Fr. in July 1918, at the higher locality. *Vern. Name*: Kahurkah (? Bal.).

Sisymbrium thalianum *Gay & Monn. in Gaud. Hely. IV. 348.* Loc.: Nagak (W. Kolwa), about 87 miles E. by N. of Turbat, about 2,400 ft. (no. 138 A). Fr. in April 1918. *Vern. Name*: Baharo (probably wrong according to Hotson).

BRASSICA *L.*

Brassica campestris *L.* Loc.: Nal, 27° 41′ N, 66° 13′ E, 3,834 ft., probably only from an accidentally dropped seed, a mile or more from any water in a barren stony plain (no. 337). Fl. in September 1917. *Vern. Name*: Mashna Muli (Brah.)

ERUCA *DC.*

Eruca sativa *Lam. Fl. Fr. II. 496.* Loc. not given. Fl. and fr. in August 1917.

CAPSELLA *DC.*

Capsella bursa pastoris *Moench. Meth. 271.* Loc.: Rakhshan river bed at Panjgur, about 3,100 ft. (no. 115 A). growing in a dry stony river bed. *Vern. Name*: Halaku (Bal.).

LEPIDIUM *L.*

Lepidium draba *L. Sp. Pl. 645.* Loc: Mazarjuh, about 28° 11′ N, 69° 2′ E. about 5,200 ft., found among wheat stubble (no. 157 E); Teghab, 107 miles S. of Kalat, about 4,150 ft. (no. 184); Panjgur, about 3,100 ft (no. M 157); Harbud (no. 157 C); Kochau, 122 miles SSW of Kalat, 4,150 ft. (no. 184 A); Harbud in Gichk, about 55 miles E. of Panjagur, about 3,700 ft. (no. 157 C). Fl. in March and April 1918. Uses: Cooked and eaten like "palak" or spinach *Vern. Name*: Garbust (Bal. Br.). "Garbust seems tc be a general name for various edible plants with little else in common." (Hotson).

Lepidium propinquum *F. & M. in Hohen. Talysch Enum.* 142. var. *auriculatum* Boiss. Fl. Or. I, 357. Loc. not given. Fl. in Aug. 1917.

Lepidium sp. Loc.: Hazarganji, 27° 28′ N, 66° 12′ E, about 3,600 ft. (no. 184 B). *Vern. Name*: Garbust (Bal. Br.).

ISATIS *L.*

Isatis latisiliqua *Stev. Mem. Mosq. III (1812) 267.* Loc.: Mitasing, about 17 miles ESE of Panjgur, about 4,000 ft. (no. 318, 318A). Fl. and fr. in April 1918. *Vern. Name*: Karkikah (Bal.).

Isatis minima *Bunge Del. Sem. Hort. Dorp. (1843) 7.* Loc.: Harbud, about 55 miles E. of Panjgur, about 3,700 ft. (no. M 312). Fl. and fr. in April 1918. *Vern. Name*: Khulif (Br.).

PHYSORHYNCHUS *Hook.*

Physorhynchus brahuicus *Hook. Ic. Pl. tab. 821 and 822.* Loc, Cracks in rocky sides of Anjiri, hills S. of Chambar (Kolwa), 26° 9′ N.

64° 42′ E, 1,900-2,200 ft. (no. 266, 266A, 266B). Fl. and fr. in April 1918. Note: The lower joint of the siliqua contains sometimes one seed, each loculus of the upper joint is either seedless or 1-seeded.

Capparidaceae.

Cleome *L.*

Cleome brachycarpa *Vahl in DC. Prodr. I. 240.* Loc.: Zahren Kahur, 16 miles N. of Pasni, about 200 ft. (no. M 38); Rari Dan, 170 miles S. by W. of Kalat, 2,300 ft. (no. 286); Korak Pelar, 180 miles S. by W. of Kalat, 1,900 ft. (no. 279). Fl. and fr. in Sept, 1917. Uses: The leaves are said to be crushed in oil and rubbed on the arms, etc., as an embrocation for high fever (Hotson). *Vern. Names*: Miskok (Bal.), Pawal (Brah.).

Cleome Hotsonii *Blatt. & Hall. spec. nov.* Herba perennis, basi lignosa, glauca, glaberrima, caulibus gracilibus ascendentibus, 25 cm altis, angulosis. Folia uniformia, elliptica, obtusiuscula, subobliqua, basi subacuta, valde obscure trinervia, carnosa, remote sparsa, infima maiora 25 mm attingentia (petiolo incluso), longepetiolata petiolo gracillimo tertiam vel dimidam partem laminae attingente, superiora minora, floralia (bracteae) minima. Racemi terminales, pauciflori, laxissimi. Pedicelli patentes fructiferi 8 mm longi, florigeri breviores. Calyx minutissimus, divisus paene ad basim, lobis ovatis, acutis, reticulatim venosis duobus tribus aliis longioribus. Petala 4, longa 7 mm, apice subulata, trinervia. Stamina 6 diversae longitudinis, petalis breviora. Gynophorus, ovarium necnon stylus in nostris speciminibus valde obscura (an rudimentaria?). Siliqua pendula, linearis, recta, utrimque attenuata, 65 mm longa, 2½ mm lata, aliquantulum compressa, membranacea, striata, stipite gracili 4 mm longo, apice cuspidata. Semina disciformia lanata, margine obtusa. This species comes nearest to C. glauca DC., but is distinguished by the following points: The petioles are much longer, the leaves are elliptic not ovate, the siliqua has a sharp cusp, is longer and narrower. Loc.: Hills near Ispikan, about 20 miles NE of Mand, 1,200—1,500 ft. (90, 90 A). Fl. and fr. in March 1918. *Vern. Name*: Shwanko (Bal.). "The name was given doubtfully" (Hotson).

Maerua *Forsk.*

Maerua crassifolia *Forsk. Fl. Aegypt. Arab. p. 113.* Maerua uniflora *Vahl.* Loc.: Hodal Pass (N. side), about 80 miles S. of Panjgur, 2,200—2,900 ft. (no. M 15 B); Nasirabad, 23 miles W. of Turbat, about 400 ft. (no. M 15 B). Common on both side of the Hodal Pass which leads from Kilkaur to Kolwa. Fl. in April 1918. *Vern. Name*: Jogar (Bal.).

Capparis *L.*

Capparis decidua *Pax in Engl. Prantl Nat. Pflanzenr. III, 2, p. 231.*--C. aphylla *Roth.* Loc.: Jatu Pass (S. side), about 36 miles S. by W. of Panjgur, 3,250 ft., comparatively uncommon in this neighbourhood (no. M 64 A); W. side of the Burida Pass, from Bhani

to Jebri, fully 140 miles SSW of Kalat, below 4,250 ft. (no. 218); Rek Chah 11 miles E. of Chambar (Kolwa), about 1,800 ft. (no. M 64B, 64C); throughout the Kolwa plain the chief feature of the landscape is the vast number of Kaler trees, all in flower (13-IV-18). The shades vary from pale salmon to deep red, but the general aspect is far more autumnal than spring-like; Siman river, 15 miles SE of Khozdar, about 3,700 ft. (no. 218 A bis); 2 miles W. of Tump i.e. 48 miles W. of Turbat, about 600 ft. (no. M 64). Fl. and fr. in March 1918, April 1917 and 1918, Sept. 1917. Uses: The fresh young twigs (tips only) are crushed and soaked in water. The water is strained off—sometimes this is done two or three times. The residuum is dried and allowed to solidify. A tiny peace of it is eaten with butter and gives relief from pain after a bruise or fall. Also makes a very strong plaster. (Hotson). *Vern. Name*: Kalir (Bal.), Kaler (Br.).

Capparis spinosa *L. Sp. Pl. 720.* Loc.: On SE side, near summit, of Gar Pass between Rakhshan and Grichk valleys, about 22 miles ESE of Panjgur, about 4,200 ft. (no. M. 286, 28 C). Fl. and fr. in April 1918. Uses: The berries are crushed; they give a lot of juice. but if they are dry, a very little water is added, and the juice is poured, not heated, into the ear as a cure for ear-ache. (Hotson). *Vern. Name*: Krap (Bal.).

Capparis spinosa var. **canescens** *Coss. Not. pl. Crit. I, 28.* Loc.: Gar Pass, about 22 miles E. by S. of Panjgur, about 4,200 ft. (no. 28 B, 28 D); hills near Ispikan, about 20 miles NE of Mnad about 1,200—1,500 ft. (no. 28A); Ornach, 3,080 ft. (no. 140A); Kuldan (W. Kolwa), about 85 miles E. by N. of Turbat, about 2,400 ft. (no. M 246); near Korak (Pelar), 180 miles S. by W. of Kalat, 1,900 ft. (no. 281); Gwambuk, about 50 miles S. by E. of Panjgur, about 2,700 ft. (no. M 28). Fl. in April 1918. Fr. in April 1918. Uses: Used as medicine for goats. The leaves are very bitter (Hotson). *Vern. Names*: Krap (Bal.), Karap (Br.), Khaf Khandar (Br. Bal.).

Capparis spinosa var. **parviflora** *Boiss. Fl. Or. I, 420.* Loc.: Kalgali Kaur, N. of Zayaki Jangal, about 4,800 ft. (no. M 28F). Shadadzai, 72 miles S. of Kalat, 5,100 ft. (no. 140). Fl. in Aug. 1917. Uses: Is boiled in water and applied as a poultice for boils. Also makes water cold. (Hotson). *Vern. Names*: Krap (Bal.), Khalkandir Khafkhandar (Br.).

Resedaceae.

OCHRADENUS *Del.*

Ochradenus baccatus *Del. Fl. Eg. 15, tab. 34, fig. I.* Loc.: Dokop, 60 miles W. of Turbat, about 700 ft. (no. M 17); junction of Raghai and Sichk rivers, about 3,600 ft. (no. M. 307); Taloi Sunt, about 50 ft. (M 17B); Hazarganji, 27° 28′ N, 66° 82′ E, about 3,600 ft. (no. 334). Fl. in Feb. 1918, April 1918, Sept. 1917, Dec. 1917. Uses: The twigs, leaves and flowers are fried, ground to a powder, mixed with a little neshar and applied dry to wounds and sores to kill maggots, etc. (Hotson). *Vern. Names*: Kalir Ram, Kirmkush (Bal.).

(*To be continued*).

CURRENT LITERATURE.

New Indian Species, etc.

Meteoromyrtus *Gamble, gen. nov. Kew Bull. 7 (1918) p. 241.* Separated from *Eugenia* Linn. in which the one species *M. wynaadensis* had been placed by Beddome chiefly because the ovules are about 4 and pendulous from the apex of the ovary.

Pygeum sisparense *Gamble sp. nov., l.c. p. 238*, allied to *P. acuminatum* Colebr. but differing in smaller leaves, shorter racemes and fewer stamens. *Dist.* In forests on the south-west side of the Nilgiri plateau about Sispara at 6,000 to 7,000 ft.

Eugenia discifera *Gamble sp. nov., l.c. p. 239* allied to *E. caleadensis* Bedd. But differing in having no peduncles and short pedicels and the dry leaves somewhat gray below. *Dist.* near Chimunji, Travancore about 4,000 ft.

Jambosa Bourdillonii *Gamble sp. nov., l.c. p. 239* allied to *Eugenia hemispherica* Wight, but differing in the nervation of the leaves being conspicuous on the under side, the very short cymes and the campanulate calyx tube. *Dist.* Travancore about 2,000 ft.

Jambosa courtallensis *Gamble sp. nov., l.c. p. 239*, a distinct species somewhat like *Eugenia Mundagam* Bourdillon in the nervation of the leaves, but differing in the leaves being much smaller and rounded, not cordate at the base, and in the elongated subcylindrical calyx tube. *Dist.* Courtallum, Tinnevelly Hills.

Syzygium palghatense *Gamble sp. nov., l.c. p. 240* allied to *S. calophyllifolia* Walp., but differing in the obovate abruptly obtusely acuminate leaves and elongate infundibuliform calyx. *Dist.* Palghat Hills, Malabar about 5,000 ft.

Syzygium travancoricum *Gamble sp. nov., l.c. p. 240* closely allied to no other species and distinguished by its long petioled leaves and small flowers in long-peduncled long-branched cymes. *Dist.* In swampy places in the low country of Travancore up to about 200 ft.

Osbeckia lineolata *Gamble sp. nov., l.c. p. 241* allied to *O. minor* Triana but differing in the leaves which are larger, elliptic, setoso-mucronate and drying yellow; and in the larger flowers and fruit. *Dist.* Nilgiris and Pulneys about 6,000 to 7,000 ft.

Osbeckia courtallensis *Gamble sp. nov., l.c. p. 242*, although similar to *O. Kleinii* W & A, in the setae of the calyx, yet differing in the smaller, elliptic, lanceolate leaves, and few flowered inflorescence. *Dist.* Courtallum, Tinnevelly.

Osbeckia Lawsoni *Gamble sp. nov., l.c. p. 242* allied to *O. Kleinii* W. & A., but differing in the acute calyx lobes and smaller leaves. *Dist.* Travancore at about 2,000 ft.

Ixora Butterwickii *Hole sp. nov., Indian Forester XLV (1919) No. I p. 15*, allied to *I. spectabilis* Wall and *I. pendula* Jack, but differing from the former in the larger size and shape of the leaves, more numerous lateral nerves and wider panicle, and from the latter in the shorter corolla tube, longer anthers and wider panicle. This species is at present known only in Burma.

Anogeissus rotundifolia *Blatter and Hallberg sp. nov., Journ. Bombay Nat. Hist. Soc. XXVI (1919) No. 2 p. 525*, differs specifically from *A. coronata* Straf in Kew Bull. 4 (1914) p. 153. *Dist.* Kailana near Jodhpur.

Pulicaria rajputanae *Blatter and Hallberg sp. nov., l.c. p. 535*, allied nearly to *P. crispa* Benth, but differing in the following points: the plant is woolly all over, the margin of the leaves is not recurved, the ligules are much longer than the bracts, the pappus is six times as long as the achenes. *Dist.* Jodhpur and Jaisalmer. Flowering and fruiting in October and November.

Glossocardia setosa *Blatter and Hallberg sp. nov., l.c. p. 536*, distinguished from *G. linearifolia* Cass. by the following characters: the plant is much larger and generally erect, the shape of the outer bracts is different, the awns of the achene spread almost horizontally and are setose, sometimes half way up, at other times along their whole length. *Dist.* Jodhpur and Jaisalmer. Fruiting in October and November.

Convolvulus densiflorus *Blatter and Hallberg sp. nov., l.c. p. 545* (near *C. rhyniospermum* Hochst), *Dist.* Jodhpur and Jaisalmer. Flowering and fruiting in October and November.

Convolvulus gracilis *Blatter and Hallberg sp. nov., l.c. p. 545. Dist.* Jodhpur. Flowering and fruiting in November.

C. T.

Distribution of Phanerogams

Guppy, H. B., Plant-Distribution from the Stand-point of an Idealist. *Jour. Linn. Soc. XLIV No. 299 (July 1919) pp. 439-472.*

It would probably not be a mis-statement to say that in regard to the origin of species and to evolution in general, the vast majority of Botanists as well as Zoologists are divided into two camps, the Darwinians who believe in progressive evolution by small changes, and the Mutationists who contend that specific differences are often, or perhaps always, caused by sudden changes; and to this camp belong also those who pin their faith on the transmission and acquirement of characters on Mendelian lines. But as far as the writer of this notice is aware in neither camp would it be denied that generic differences have in the past arisen out of smaller (specific) beginnings, and have in turn led to the larger differences which separate the orders or families as we know them to-day. Mr. Guppy in the paper under notice contends that the present distribution of the families of plants, the great majority (over 70 per cent.) of which occur in both the Old and the New World, points to an even distribution in some bygone age over the whole globe; an age when conditions were much more uniform than at present and when first the larger groupings then the families were segregated. The splitting up of these families into genera and then into species followed in another era when climatic differentiation had become established. In other words evolution has been not from small differences growing into larger, but by the laying down first of the major lines of cleavage between plant groups, and the subsequent splitting up of those groups into smaller ones.

In a series of tables at the close of the paper it is shown that the idea usually held that the junction in the north of the two great land masses of America and Eurasia has afforded opportunity under suitable climatic conditions for a mixing of the floras of these two areas, is not borne out by statistical evidence in the case of the families, only partly so in regard to the genera, but much more so with the species. It is also shown that while the majority of families ignore in their distribution the existence of the ocean barriers between these two parts of the land, they are very much affected by

the climatic zonation. Also that of the different great groups of the Flowering plants the Monocotyledons are predominantly tropical, the Sympetalæ least so, and this lagging behind by the Monocotyledons in escaping from the tropics may perhaps be explained by the vastly greater proportion of aquatic orders in this group, though this is probably not the whole explanation.

The paper begins with a reference to papers on the distribution of the Compositæ, by Bentham and of Gentianaceæ by Huxley, in both of which an original even distribution of the family was postulated, and the work of Dr. Willis on the Podostemaceæ, which in spite of absolutely uniform conditions show the greatest amount of floral and other differentiation is quoted as lending support to the idea that in an age of great uniformity of conditions it might be possible to have the greatest instability of essential characters, which later on became fixed with the gradual progressive differentiation of conditions.

P. F. F.

Ecology.

Sedgwick, L. J., Analyses of some morphological characters of Bombay woody species from an Oecological stand-point. *Indian Forester 1919 pp. 193—9.*

This paper arose the author says 'from a desire to test the 'drip-tip' theory of Stahl' but he included investigation on armature and methods of seed-dispersal. The leaf-tip he classifies under seven heads from 'very long acuminate' to very obtuse with an eighth class of plants leafless in the mature state, for xerophytes. Acute or acuminate tips are a feature of the evergreen forests of his region (with 83 per cent.), but among xerophytes there are 35 per cent, not much fewer than with obtuse apices (41 per cent.); and the author believes the acuminate leaf-apex is only the result of general good development owing to favourable circumstances at the end of the chief vascular bundle. Thorns and spines too he finds chiefly developed among xerophytes but also in some evergreen trees, and since goats and camels eat thorny Acacias without seeming to mind the thorns, he denies in this case too any teleological explanation, and puts down the hardening of the thorns simply to the tendencies of general development. To this most people will probably agree, for that the development of spines and prickles is furthered, and even initiated, by dryness has been proved by Lothelier with *Ulex*, and by other workers.

P. F. F.

Histology

Balls, W. L., Growth-rings in the Cell Wall of Cotton Hairs *Proc. Rag. See B. 90 No. B 634, p. 542* with 4 text-fig and 5 mino-photographs.

By suitable treatment of cotton hairs to make the wall swell, the author demonstrates the existence of concentric layers, corresponding to the daily growth in thickness of the cell-wall interrupted as it is each afternoon by the sun-heat. Previous work had shown that the growth in thickness of the wall, and the formation of simple pits began on the 21st to 25th day of the

formation of the fruit, and the author had before been led to the conclusion that growth in thickness took place every night, and might be expected to show itself in about 25 concentric layers. The process and methods now described prove this supposition correct. Owing to the thinness of the wall each layer is only about 0·4 ft, in thickness, or less than the wave length of yellow light. Hence the necessity for a very considerable swelling of the hair, but with the proper treatment as above the stratification could be seen with a $\frac{1}{6}$ inch objective.

P. F. F.

Osterhout. W. G. V. Tolerance of fresh water by Marine plants and its relation to adaptation *Bot. Gaz. 63; 146-149; 1917.*

Osterhout points out " the remarkable differences between marine plants and even between different cells of the same plant with respect to their tolerance of fresh water " and gives an interesting discussion on the theory of adaptation. *Polysiphonia violacca* is given as an instance where death takes place with great rapidity on transference to fresh water. Various others, representative of the red, brown, green and blue green algæ showed extreme tolerance of fresh water. One particular instance is, where, at the mouth of a brook, all kinds of algæ were exposed alternately to 6 hours of fresh water and 6 hours of salt water between the tides. *Zostera maritima* is found in places where the roots are constantly in salt water while the leaves are alternately under salt and fresh water. It is found that the roots of this plant die in a few minutes in fresh water. This difference between the roots and leaves is in accordance with the theory of adaptation as the leaves under such conditions will be expected to be more tolerant of fresh water than the roots. But the same differences between roots and leaves are also found in plants of the same species growing constantly in sea water " where no opportunity for adaptation to fresh water occurs." The author remarks " that characters which seem to be the result of adaptation were in this case present from the beginning and must be ascribed entirely to different causes."

T. E.

Heredity.

Bateson, W., Studies in Variegation—*Journal of Genetics VIII No. 2. (April 1919) pp. 93—98 3 col. pl.*

The author draws attention to the two forms of variegation due to deficiency of chlorophyl in (*a*) the skin a epidermal layer, so that there is a white skin on a green core, and in (*b*) the middle of a leaf, so that there is a green skin over a white core. This last is much less common than the other. Variegated plants of the first kind, however fertilised, always give white or albino offspring which of course do not live long. The leaves have usually a white edging and green centre. In the second kind the leaves have a green edging and pale centre.

Two instances were noticed of a reversal i.e., of a variegated plant of the kind (*a*) bearing a shoot of (*b*). These were in variegated varieties of *Euonymus japonicus* and *Pelargonium*.

Variegated plants though not of these genera are so commonly grown in our Indian gardens and are so easily propagated, that it seems worth while suggesting an examination of the plants in gardens, for other instances of reversal. Interesting problems of heredity are bound up with the inheritance of these chimaeras. P. F. F.

Algae.

Bristol, B. M., Miss., On a Malay form of Chlorococcum humicola (Nag) Rahenbh. *Jour. Linn. Soc. Bot. XLIV, No. 299, (July, 1919) pp. 473—480, pl.*

A specimen of soil from Kajang, Malay States, which had been air-dried and stored for two years, was put in a suitable culture-fluid, and after some eight months an alga was found which soon developed quite healthily and proved to be in no way different from the English *Chlrococcum humicola.*

Germination was certainly slower, and the cells larger, but the author points out that the size varies in the cultures a very great deal, cells being measured from 20 to 80 in diameter. The formation of both zoogonidia and of aplanospores was observed, and in the former an abnormal form seen where owing to the liberation of the zoogonidia before the division had been completed, a triangular body appeared with pairs of cilia at the three corners. The author explains the parmella stage which follows the formation of aplanospores as idicating that the latter are " really reduced zoogonidia, but that the surrounding nutrient conditions are such as to be able to support the devolopment of a large number of individuals in a small space, and to render their wider distribution unnecessary ", a teleological explanation which seems hardly sufficient to account for the palmella stage. As illustrating the extraordinary resistance of the spores to desiccation the author gives her experience with samples of soil which were collected as long ago as 1846, and 1856 from a plot at Rothamstead. From the former she did not obtain any growth, but did from the latter, which shows that the limit of retention of vitality lies between 70 and 80 years.

P. F. F.

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Note to Contributors

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All matter for the printer should be typed and on one side of the paper only. The name of a genus should begin with a capital letter, but that of the species only when it is adapted from a proper name (Vienna Rules). No comma should be put in after the specific name and before that of the founder of the species. The Editor will see to the type but the writer may, if he likes, indicate it on the following lines. The name of a plant at the opening of a paragraph or when it is desired to direct special emphasis to it may be underlined wavy (~~~~~~~~~~) for printing in **antique** type, with the founder's initial or name underlined plain _____) for *italics* ; thus **Acalypha indica** *L.* If in the middle of a paragraph the name should be underlined plain, but the founder's initial not, thus *Acalypha indica* Linn.

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THE PHYSIOLOGICAL ANATOMY OF THE PLANTS OF THE INDIAN DESERT

BY

T. S. SABNIS, B.A., B.Sc.

St. Xavier's College, Bombay.

(*Continued from last issue.*)

Cleome brachycarpa *Vahl.* Figs. 13, 14, 19, 20, 21. Herbaceous. Front cavity of stomata on a level with the surface. Guard-cells a little above the plane of the surrounding cells. Mesophyll isobilateral. Some of the palisade cells with tanniniferous contents. Middle tissue of the mesophyll formed of large colourless parenchymatous cells. Veins provided with colourless sheaths. Glandular hairs multicellular and capitate. Outer walls of the epidermal cells of the axis granulated. Axis ribbed. Pericycle formed of large thin groups of stone-cells. Assimilatory tissue in the axis consisting of chlorenchyma. Wood composite. Soft bast forming a continuous ring. Pith formed of thin-walled cells.

Cleome viscosa *L.* Figs. 15, 16, 28. Herbaceous. Epidermis of the leaf formed of thin-walled cells. Guard-cells elevated a little above the plane of the surrounding cells. Front cavity of the stomata in a level with the surface. Mesophyll formed of palisade tissue on the adaxial side and of arm-palisade tissue on the abaxial side. Internal glands absent. Glandular hairs multicellular and capitate. Veins not provided with sheaths. Stone-cell groups of the pericycle triangular. Assimilatory tissue of the axis formed of chlorenchyma. Wood composite. Soft bast forming groups. Pith formed of thin-walled cells.

Gynandropsis pentaphylla *DC.* Figs. 22, 23, 24, 25, 26, 29. Herbaceous. Guard-cells a little elevated above the plane of the surrounding cells. Mesophyll formed of palisade tissue on the adaxial side and of spongy tissue on the abaxial side. Internal glands absent.

Veins provided with green sheaths. Glandular hairs multicellular and capitate. Epidermis of the axis two-layered. Pericycle formed of rhomboidal stone-cell groups. Wood composite. Soft bast forming a continuous ring. Pith formed of thin-walled cells.

Cadaba indica *Lam.* Figs. 30, 31, 32, 33, 34, 35. Woody. Outer walls of the epidermal cells of the leaf greatly thickened and papillose. Guard-cells in the plane of the surrounding cells. Mesophyll formed wholly of short palisade cells. Internal glands in the leaf in the form of parenchymatous cells with tanniniferous contents. Veins not provided with sheaths. Water-storing tracheids occurring at the terminations of the veins. Clothing hairs peltate. Glandular hairs absent. Outer walls of the epidermal cells of the axis superficially granulated and lateral walls thickened. Pericycle formed of rhomboidal groups of stone-cells. Wood forming a composite ring; soft bast forming a continuous ring.

Capparis decidua *Pax.* Figs. 27, 36, 37. Woody. Leaves occurring only on young shoots. Epidermis of the leaf and axis formed of vertically elongated highly thick-walled cells. Mesophyll isobilateral with an extensive middle tissue of parechymatous cells. Internal glands in the form of numerous cells with tanniniferous contents. Veins not provided with sheaths. Pits present in the epidermis of the axis. Assimilatory tissue in the axis formed of palisade cells. A ring, 1-2 cell thick, of sclereids occurring below the assimilatory tissue. Pericycle formed of rhomboidal groups of stone-cells. Wood formed of xylem bundles connected by strands of interfascicular wood-prosenchyma. Soft bast forming groups. Pith composed of thin-walled cells.

Structure of the Leaf

Epidermis.—Outer walls are thickened and somewhat papillose in all members except *Cleome viscosa* (fig. 16.) The thickening and papillose differentiation is considerable in *Cleome papillosa* (fig. 11), *Cadaba indica* (fig. 30), *Gynandropsis pentaphylla* (fig. 22) and *Capparis decidua*. Lateral walls are thin in all the numbers except *Capparis decidua*, where they are thickned; they are somewhat undulate in all the members. Epidermal cells at the margin are rounded forming the marginal epidermis compact and rigid. Some of the lower epidermal cells in *Cleome brachycarpa* are larger and longer than broad, perhaps serving as water-reservoirs. Epidermal cells at the margin and along the mid-rib are smaller than in the other part of the leaf blade.

Stomata are surrounded by four to six ordinary epidermal cells (fig. 19) and are more numerous on the under surface. They are placed in depressions formed by the outer thickened and papillose

walls of the epidermal cells in *Cleome papillosa* (fig. 11), *Cadaba indica* (figs. 30, 31) and *Capparis decidua*, the guard-cells being situated in the plane of the surrounding cells. In the other members the guard-cells are elevated above the plane of the surrounding cells, so that the front cavity is on a level with the surface (figs. 23, 27.).

The mesophyll is composed of palisade tissue on the adaxial side in all the members and on the abaxial side of arm-palisade tissue in *Cleome viscosa* (fig. 16) or of spongy tissue in *Gynandropsis pentaphylla* (fig. 22). The mesophyll is isobilateral and is composed wholly of short palisade cells in *Cadaba indica* (fig. 30) or composed of palisade tissue on either side with a middle tissue of thin-walled colourless parenchymatous cells in *Cleome brachycarpa* (fig. 14) and *Capparis decidua*. The middle tissue in the former partakes in the formation of bundle-sheaths; and in the latter it is very extensive and forms perhaps a water-storage tissue. Internal secretory organs are of the nature of myrosin cells and are represented by (a) palisade like cells occurring in small groups on both sides below the epidermis in *Cleome viscosa* or (b) by parenchymatous cells in the middle tissue in *Cadaba indica* (fig. 30) and in *Capparis decidua* commonly occurring near the veins and quite numerous above the bundle of the mid-rib. The veins are embedded in all the members. They are provided with a sheath either of large colourless parenchymatous cells or of distinct green parenchymatous cells in *Cleome brachycarpa* (fig. 14) and *Gynandropsis pentaphylla* (fig. 22) respectively. Groups of large water-storing tracheids occur at the terminations of the veins in *Cadaba indica* (fig. 30 W). The vascular bundles of the mid-rib are arranged in the form of an arc with collenchyma on the lower side extending to the epidermis. The mid-rib projects on the lower side.

The hairy covering of the leaf and axis consists of (a) clothing and (b) glandular hairs.

(a) Clothing hairs are not unicellular in any of the members. *Cleome papillosa* and *Cleome brachycarpa* have shaggy hairs, the cells of which end superficially in sharp spiny apices (figs. 10, 11, 12). In *Cadaba indica* there are peltate hairs composed of a uniseriate stalk, much longer on the axis, and of a circular shield which in surface view presents a notched margin (fig. 33). Hairs are more numerous on the lower side of the leaf and especially on the mid-rib.

(b) Glandular hairs are present on the leaf and axis in all members except *Cadaba indica*. They are composed of a multicellular head irregularly divided (figs. 11, 13, 18). They are not numerous either on the leaf or axis; they are however more common

on the margin of the leaf. They are numerous and longer on the axis than on the leaf (fig. 26). In *Cleome brachycarpa* there are a few multicellular glandular hairs with a spiny curved apex (fig. 20).

Structure of the Axis

Epidermis consists of small cells with outer and inner walls thickened. Lateral walls are also thickened in *Cleome papillosa* and *Cadaba indica*. Epidermis is two-layered in *Gynandropsis pentaphylla*. Outer walls are superficially granulated in species of *Cleome*. Epidermis of *Capparis decidua* consists of vertically elongated small cells with outer walls greatly thickened and cuticularised. Epidermis of *Capparis decidua* is characterised by numerous small pits which in T. S. are bounded laterally by two ordinary epidermal cells and beneath by a curved cell. Viewed from the surface the pits resemble small square holes bounded by 4-5 cells. These pits may possess the function of stomata without any regulating apparatus. The axis of *Cleome brachycarpa* and *Cleome viscosa* is ribbed, the ribs being strengthened by collenchyma. In *Cleome brachycarpa* there are some large cells intercalated among the small epidermal cells of the ribs with perhaps partly a water-absorbing and partly a strengthening function.

The stomata are surrounded by 4-6 ordinary epidermal cells as seen in surface view. The front cavity is placed in a depression produced by the outer thickened epidermal walls. The guard-cells are in the plane of the surrounding cells. Stomata are replaced by pits in *Capparis decidua*, as described already.

Primary cortex is characterised by an assimilatory tissue composed of chlorenchyma, except in *Capparis decidua* where it is replaced by the palisade tissue. In *Capparis decidua* there are sclereids in a ring below the assimilatory tissue. The sclereids have thickened and radially striated walls and are characterised by pitted markings.

The pericycle is represented by groups of stone-cells, either thin and long as in *Cleome brachycarpa* and *Cleome papillosa*, or triangular as in *Cleome viscosa* or rhomboidal as in other species.

The structure of the wood can be seen from the following table. (p. 71.)

The soft bast forms a continuous ring as in *Cleome brachycarpa*, *Cadaba indica* and *Gynandropsis pentaphylla*, or forms groups as in other members.

The pith is either composed of thin-walled cells as in *Cleome brachycarpa*, *Cleome viscosa* and *Gynandropsis pentaphylla*, or of thick-walled cells, as in other species.

Name of the Species.	Vessels.			Wood-Prosenchyma		Medullary-Rays		General Remarks.
	Size.	Abundance.	Arrangement.	Size.	Abundance.	Size.	Abundance.	
Cleome papillosa.	Small	Few	In groups of rows.	Large-lumen.	Not extensive.	1..... Seriate.	Few.	Wood composite.
Cleome brachycarpa.	Large	Numerous.	In groups of 2-4 rows.	,,	,, ,,	,,	,,	,, ,,
Cleome viscosa.	,,	Few	In groups of very incomplete rows.	,,	Extensive.	Absent.	,,	,, ,,
Gynandropsis pentaphylla.	Small	,,	In rows and projecting into pith.	,,	,,	,,	,,	,, ,,
Cadaba indica.	,,	,,	In single rows and few.	Small	,,	1..... Seriate.	Numerous.	,, ,,
Capparis decidua.	Large	,,	In very incomplete single rows.	Large	,,	Absent.	...	Wood composite. Groups of sclerenchymatous cells at the lower end of the vessel-rows.

General Review:—Outer walls of the epidermal cells are thickened. Guard-cells are accompanied by ordinary 4-6 epidermal cells and are usually elevated above the plane of the surrounding cells. The mesophyll is either composed wholly of palisade tissue or is isobilateral, or is composed of palisade tissue on the adaxial side and of arm-palisade tissue or spongy tissue on the abaxial side. Internal secretory cells with tanniniferous contents are usually present in the leaf. The veins are embedded and are in some species provided with bundle-sheaths. Water-storing tracheids occur in the leaf and axis in some species. Mutlicellular capitate glandular hairs are of common occurrence. Peltate clothing hairs are present in *Cadaba indica*. Primary cortex is characterised by an assimilatory tissue composed either of chlorenchyma or of palisade tissue. The pericycle is composed of groups of stone-cells. The structure of the wood is composite. The soft bast forms a continuous ring or occurs in groups. The pith is composed either of thin-walled or of thick-walled cells.

VIOLACEAE.

Viola Stocksii *Boiss.*—Epidermal cells of the leaf and axis with inner walls gelatinised and with outer walls thickened and muriculate. Palisade-like elongation of the epidermal cells characteristic of the axis. Stomata present on both the surfaces. Guard-cells elevated above the plane of the surrounding cells. Mesophyll formed of palisade tissue on the adaxial side and of arm-palisade tissue on the abaxial side. Internal secretory organs absent. Oxalate of lime in the form of large clustered crystals in the leaf. Veins embedded and not provided with bundle-sheaths. Hairy covering absent. Sclerenchymatous pericycle absent. Wood composite. Vessels small and arranged in numerous complete rows. Medullary rays uniseriate Collenchyma occurring at the inner margin of the wood. Pith composed of thin-walled cells.

Structure of the Leaf:—The epidermis is composed of tabular cells, with outer walls thickened, muriculate and convexly arched outwards, and with inner walls gelatinised. Lateral walls are wavy. The marginal epidermal cells have outer as well as inner walls thickened. The gelatinised inner walls of the epidermis can absorb and retain water. The epidermis thus forms a kind of water-storing tissue. Stomata occur on both the surfaces. Guard-cells are elevated and are accompanied by subsidiary cells. The front cavity is on a level with the surface. The mesophyll is composed of palisade tissue on the adaxial side and of arm-palisade tissue on the abaxial side. Internal secretory organs do not occur either in the leaf or axis.

Numerous large clustered crystals of oxalate of lime occur in the arm-palisade tissue of the mesophyll. The crystals are wanting in the axis. The veins are embeded and are not provided with bundle-sheaths.

Both the leaf and the axis are devoid of hairs. The absence of hairs is compensated for by the gelatinisation of the inner walls of the epidermal cells.

Structure of the Axis :—Epidermis consists mostly of tabular cells with outer walls thickened, muriculate and convexly arched outwards. The inner walls are gelatinised and the lateral walls are straight. The epidermis is distinguished by two common features (1) palisade-like elongation of the epidermal cells in some parts (2) gelatinisation of the inner walls of the epidermal cells which are sometimes characterised by thin dividing walls parallel to the surface beneath which mucilage is found. The epidermis may occasionally serve as a water-storing tissue on account of these two features.

Cells of the outermost layer of the cortex show collenchymatous differentiation at their outer angles. The cortex is distinguished by the occurrence of cortical vascular bundles in the cortical chlorophyll containing parenchyma.

Sclerenchymatous pericycle is absent. The structure of the wood is composite. The vessels are small and are arranged almost in numerous complete rows. Interfascicular wood-prosenchyma is little developed. Medullary rays are uniserate and numerous. Small-celled collenchyma occurs at the inner margin of the wood. Soft bast forms a continuous ring.

The pith consist of thin-walled cells.

POLYGALACEAE.

Polygala erioptera *DC.*—Figs. 38, 39. Leaf and axis.—Numerous lysigenous cavities in the lower half of the mesophyll. Clustered crystals occurring near the veins. Compact bundles, comb-like at their ends, of diamond shaped bodies in the palisade-like cells in the upper half of the mesophyll. Epidermis of the axis two-layered. Axis ribbed. Ribs strengthened by stone-cell groups. Assimilatory tissue of the axis formed of palisade tissue. Sclerenchymatous pericycle in the form of groups of thick-walled and stratified bast fibres with small lumen.

Polygala irregularis *Boiss.*—Figs. 40, 41. Axis only.—Axis ribbed, groups of stone-cells strengthening the ribs. Epidermis one-layered. Assimilatory tissue composed of chlorenchyma. Aqueous cells between the groups of bast fibres. Sclerenchymatous

pericycle forming a loose ring of bast fibres. Oxalate of lime not occurring in any form.

Structure of the Leaf :—Epidermis in *P. erioptera* consists of tabular cells with outer and inner walls arched convexly outwards and inwards respectively. Outer walls are thickened ; lateral walls are thin and straight.

Stomata occur on both the surfaces of the leaf. The guard-cells are surrounded by ordinary epidermal cells and are situated in the plane of the surrounding cells (figs. 38, 41). The front cavity is arched over by outer horns of the guard-cells, which are quite prominent and come close together. The front cavity is placed in a depression formed by the outer thickened walls of the epidermal cells. Stomata on the axis (fig. 41) of both the species have the same characters as those on the leaf of *P. erioptera*. The mesophyll is composed of the palisade tissue on the upper side and of arm-palisade tissue on the lower. There are numerous lysigenously formed cavities in the arm-palisade tissue (fig. 38 L.C.) ; they may occasionally serve for storing water.

Oxalate of lime occurs in the form of clustered crystals near the veins of the leaves and in the assimilatory tissue of the axis of *P. erioptera* (figs. 38, 39). Besides the clustered crystals, there are elongated compact bundles of diamond shaped bodies, in the palisade tissue of the leaf ; these bundles are comb-like at their ends on account of the projecting pointed ends of the diamond shaped bodies. As regards composition of these bodies, I cannot say anything. Oxalate of lime is not found in any form in *P. irregularis*.

Veins are few and are embedded ; they are enclosed in bundle-sheaths of thin-walled colourless cells.

Hairy covering on the leaf and axis in both the species consists of unicellular thin-walled clothing hairs, either straight or hooked, and distinguished by knob-like thickenings on their walls. Glandular hairs are not found.

Structure of the Axis :—Epidermis is two-layered in *P. erioptera* while it is single layered in *P. irregularis*. Epidermal cells are tabular with outer-walls greatly thickened. Outer walls are convexly arched outwards in *P. irregularis*. Cuticle is thick, especially so in *P. erioptera*. Lateral walls are straight. The primary cortex functions as the assimilatory tissue and is composed of chlorophyll containing parenchyma in *P. irregularis* and of palisade tissue in *P. erioptera*. Groups of stone-cells occur in the ribs.

The pericycle is composed of a more or less continuous ring of bast-fibres, which are thickened, straitified and have a narrow lumen in *P. erioptera*. The ring is of uniform breadth in *P. erioptera*, while

in *P. irregularis* it is single layered on a small portion on one side, indicating the prostrate or inclined nature of the axis, sclerenchymatous pericycle being least developed on the lower side of the axis. There are thin-walled colourless cells between and on either side of some of the groups of bast-fibres in *P. irregularis*; they may occasionally serve as acqueous cells.

The wood is composite with vessels uniformly distributed in the interfascicular wood-prosenchyma. In *P. irregularis* the vascular ring is narrowed on the side where the sclerenchymatous pericycle is reduced; there are very few vessels in this portion which is mostly occupied by interfascicular wood-prosenchyma. This may be accounted for by the fact of less vigorous functional activity on the lower side of the prostrate or inclined axis of *P. irregularis*. Vessels are large and few and are arranged in incomplete rows. Medullary rays are usually uniseriate and numerous.

The pith is composed of very thin-walled cells.

CARYOPHYLLACEAE.

Polycarpaea corymbosa *Lam.*—Figs. 42, 43, 44. Epidermal cells of the leaves with outer walls thickened and papillose. Guard-cells accompanied by subsidiary cells. The front cavity greatly depressed in the axis. Mesophyll isobilateral. Abundance of cells with tanniniferous contents characteristic of the leaf and axis. Oxalate of lime in the form of clustered crystals. Assimilatory tissue in the axis formed of chlorenchyma. Pericycle composed of large groups of stone cells with a sclerenchymatous tissue on its outer side. Wood composed of large xylem bundles separated by strands of tissue, resembling medullary rays, continuous with the outer sclerenchyma. Large water-storing tracheids with reticulate markings in the xylem bundles near the medullary-ray-like strands. Pith formed of thick-walled cells.

Structure of the Leaf :—The epidermis consists of polygonal cells with outer walls thickened and papillose (fig. 42). The cuticle is smooth. The lateral and inner walls are thin and the former are wavy.

The stomata occur on both the surfaces and the guard-cells are accompanied by subsidiary cells. The guard-cells are elevated and the front cavity is placed in a depression formed by the papillose outer epidermal walls. The stomata on the axis are greatly depressed, as the guard-cells are situated below the surrounding cells (fig. 43). In addition to the subsidiary cells, there are sometimes found one or more cells clasping the guard-cells on one or both sides of the stomata on the axis (fig. 43).

The mesophyll is isobilateral and is composed of palisade tissue.

Internal secretory organs are represented by secretory cells with tanniniferous contents in the leaf and axis. In the leaf they are polygonal and lie in the lower half of the mesophyll. In the axis there is a sub-epidermal secretory tissue of one or two layers of tabular cells. Besides, there are numerous outer sclerenchymatous fibres and numerous pith cells with tanniniferous contents. Some of the cells of the medullary-ray-like strands also hold tanniniferous contents. The secretory cells with tanniniferous contents seem to be a characteristic feature of the species.

Oxalate of lime is abundantly found in the form of large clustered crystals near the veins in the leaf. In the axis cells with clustered crystals occur in the outer sclerenchymatous fibres, in the cells of the medullary-ray-like strands and in the pith.

The abundance of tanniniferous substance and of oxalate of lime in the leaf and axis gives an acrid taste to the tissues of the plant and makes it inedible by animals. Abundance of tannin also protects the tissue of the plant from desiccation. The veins are enclosed in green bundle-sheaths. Larger veins occur as usual in the middle of the mesophyll. Besides these, there are smaller veins near the lower epidermis. The vein of the mid-rib is protected above and below by strands of sclerenchyma and is vertically transcurrent below by colourless parenchyma.

The leaf and axis are devoid of clothing and glandular hairs.

Structure of the Axis :—The epidermis consists of small tabular cells with outer and inner walls very greatly thickened. Outer walls are convexly arched outwards. Lateral walls are straight. The cuticle is thick and smooth.

The cortex is characterised by a sub-epidermal tissue of tabular cells with tanniniferous contents. The assimilatory tissue which lies below the secretory tissue is composed of chlorophyll containing parenchyma.

The pericycle is composed of large groups of stone cells situated on the radii of the vascular bundles. Besides these pericyclic groups of stone cells, there is a tissue of sclerenchymatous fibres with larger lumina, continuous with the medullary-ray-like structures between the vascular bundles. There are a few scattered stone cells with walls much thickened and radially striated and with small lumina, on the outer margin of the sclerenchymatous tissue and in the soft bast.

The wood is composed of large xylem bundles separated by broad strands of radially elongated thick-walled cells resembling medullary-ray cells. These seem to be continuous with the sclerenchymatous tissue outside the pericyclic groups of stone cells.

There are isolated cases of sclerotic cells with canals, as large

in size as the vessels and situated on the upper side of the xylem near the medullary-ray-like strands. Interfascicular wood-prosenchyma is not developed. Wood-parenchyma occurs in groups at the inner margin of the xylem bundles.

The pith is composed of thick-walled cells.

PORTULACEAE.

Portulaca oleracea *L.* (Leaf only).—Clustered crystals in the leaf small and numerous.

Portulaca quadrifida *L.* (Leaf and Axis). Clustered crystals in the mesophyll large and few.

Structure of the Leaf :—The epidermis is composed of polygonal cells with outer and inner walls thickened. The outer walls are arched convexly outwards and are granulated. Stomata are more numerous on the lower surface. The guard-cells are elevated and accompanied by subsidiary cells. The front cavity is on a level with the surface. The mesophyll is composed almost wholly of aqueous tissue, the vascular bundles of the veins being surrounded by palisade parenchyma. Internal secretory organs occur neither in the leaf nor in the axis.

Oxalate of lime occurs in the form of clustered crystals in the aqueous cells of the mesophyll and in the cortex and pith of the axis.

The veins are embedded and are not provided with bundle sheaths; they are surrounded by palisade parenchyma.

The leaf and axis are devoid of hairs.

Structure of the Axis :—The epidermal cells are polygonal with outer and inner walls greatly thickened. The outer walls are convexly arched outwards and are granulated. The stipular rings of silvery long hairs reflect light and protect the axis and leaves against intense light and heat.

The cortex is formed on its outer side of an extensive tissue of thin-walled parenchymatous cells filled with starch granules and on its inner side of chlorophyll containing parenchyma. The cells of the outermost layer of the cortex are collenchymatous. The cortex may occasionally form an aqueous tissue.

The sclerenchymatous pericycle is not developed.

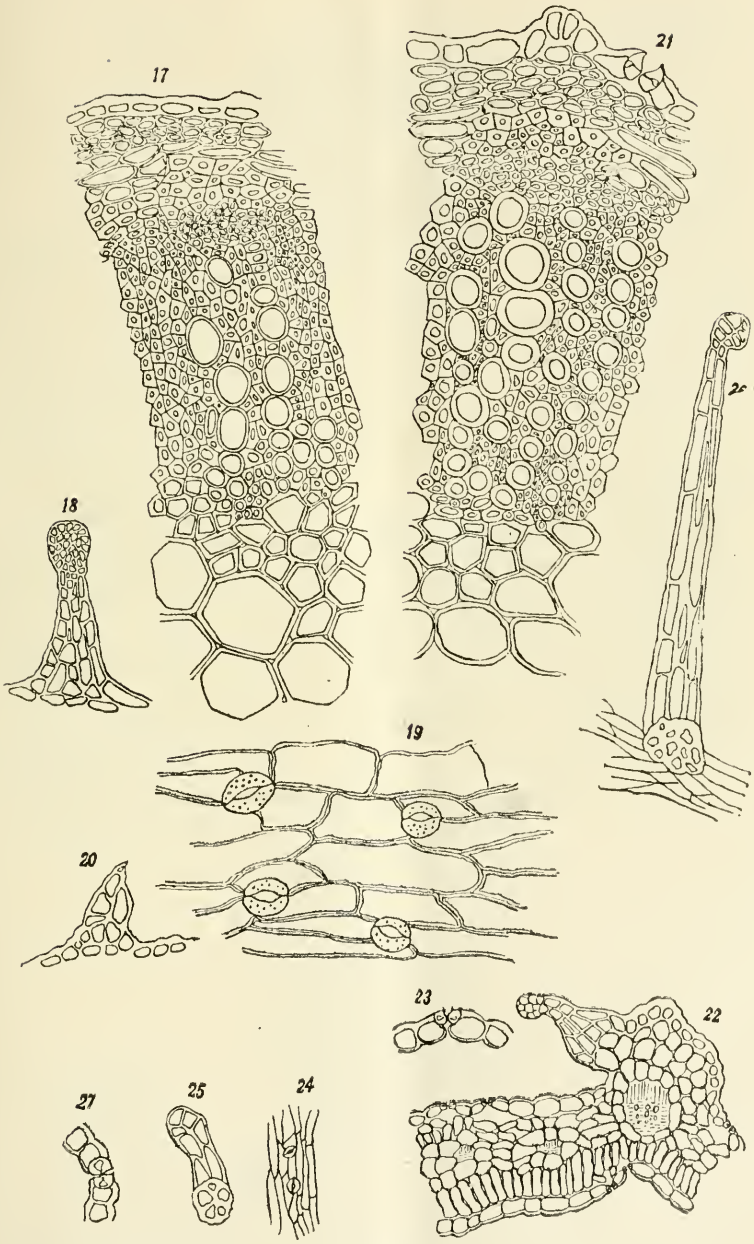
The vascular system is composed of deeply placed vascular bundles separated by thin-walled uniseriate medullary rays. Vessels are small and are arranged in complete rows. The vascular ring is surrounded by green parenchyma. The nearness of the assimilatory tissue to the vascular bundles brings about a quick distribution of the products of assimilation.

(*To be continued.*)

Plate III.

17-18 *Cleome papillosa.*
17 T. S. of the axis.
Oc. 5 ; Ob. C.
18 Hair on the axis.
Oc. 1 ; Ob. C.
19-21 *Cleome brachycarpa.*
19 Epidermis of the axis.
Oc. 3 ; Ob. C.
20 Hair on the axis.
Oc. 1 ; Ob. C.
21 T. S. of the axis.
Oc. 1 ; Ob. 3 mm. Ap.
22-26 *Gynandropsis pentaphylla.*
22 T. S. of the leaf.
Oc. 4 ; Ob. C.
23 Stoma in the T. S. of the leaf.
Oc. 1 ; Ob. 3 mm. Ap.
24 Stoma in surface view on the axis.
Oc. 1 ; Ob. C.
25 Hair on the leaf.
Oc. 3 ; Ob. C.
26 Hair on the axis.
Oc. 3 ; Ob. C.
27 *Capparis decidua.*
Stoma in T. S.
Oc. 1 ; Ob. 3 mm. Ap.

N.B.—To get the original dimensions multiply by 1·8.

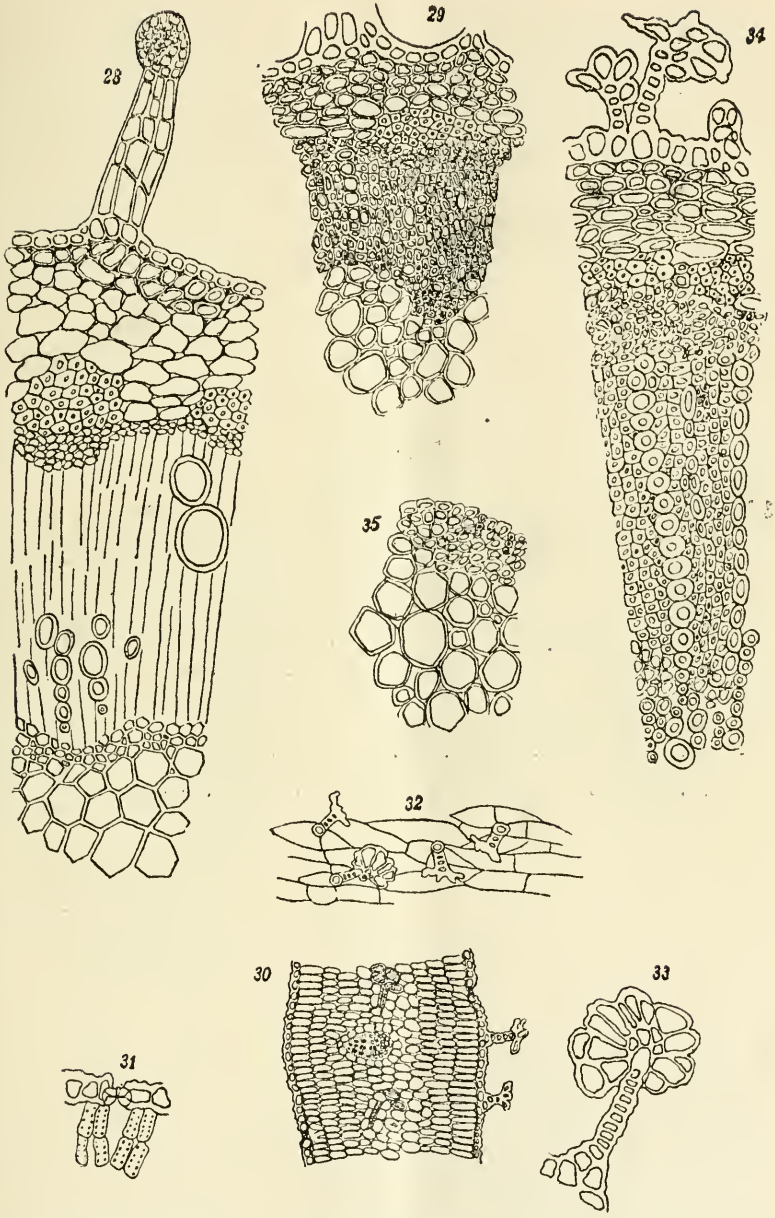


T. S. Sabnis del. PLATE III.

Plate IV.

28 *Cleome viscosa.*
T. S. of the axis.
Oc. 1; Ob. 3 mm. Ap.
29 *Gynandropsis pentaphylla.*
T. S. of the axis.
Oc. 1; Ob. 1/6 Becks.
30-35. *Cadaba indica.*
30. T. S. of the leaf.
Oc. 2; Ob. C.
31 Stoma in the T. S. of the leaf.
Oc. 4; Ob. 3 mm. Ap.
32 Epidermis of the axis.
Oc. 1; Ob. 3 mm. Ap.
33 Hair on the axis.
Oc. 4; Ob. 3 mm. Ap.
34 T. S. of the axis as far as the pith.
Oc. 5; ob. C.
35 T. S. of the axis showing the pith.
Oc. 5 : Ob. C.

N.B.—To get the original dimensions multiply by 1·7.

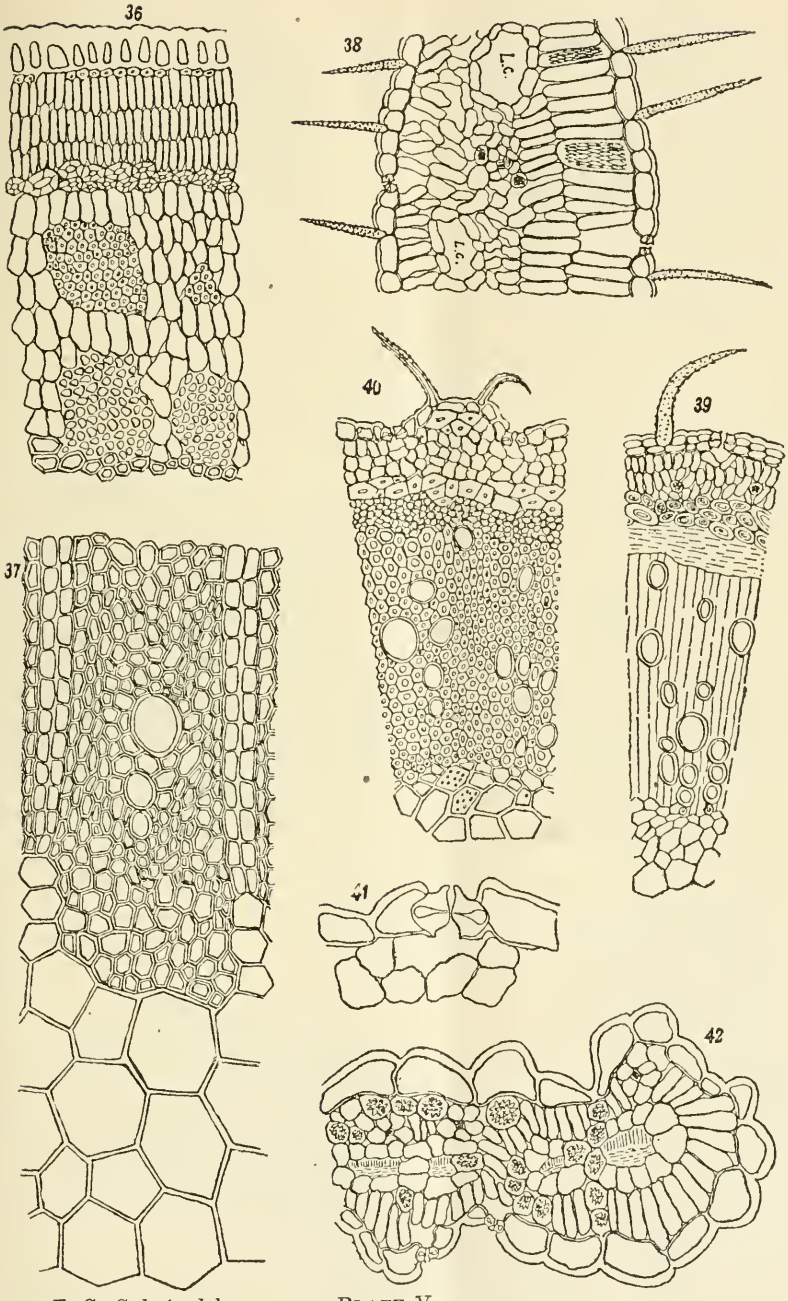


T. S. Sabnis del. PLATE IV.

Plate V.

36-37 *Capparis decidua.*
36 T. S. of the axis as far as the wood.
Oc. 5 ; Ob. C.
37 T. S. of the axis showing the wood and pith.
Oc. 5 ; Ob. C.
38-39 *Polygala crioptera.*
38 T. S. of the leaf.
Oc. 6 Com ; Ob. 8 mm. Ap.
39 T. S. of the axis.
Oc. 6 Com. ; Ob. 8 mm. Ap.
40-41 *Polygala irregularis.*
40 T. S. of the axis.
Oc. 6 Com. ; Ob. 8 mm. Ap.
41 Stoma in the T. S of the axis.
Oc. 6 Com. ; Ob. 3 mm. Ap.
42 *Polycarpæa corymbosa.*
T. S. of the leaf.
Oc. 8 Com ; Ob. 8 mm. Ap.

N.B.—To get the original dimensions multiply by 1·7.



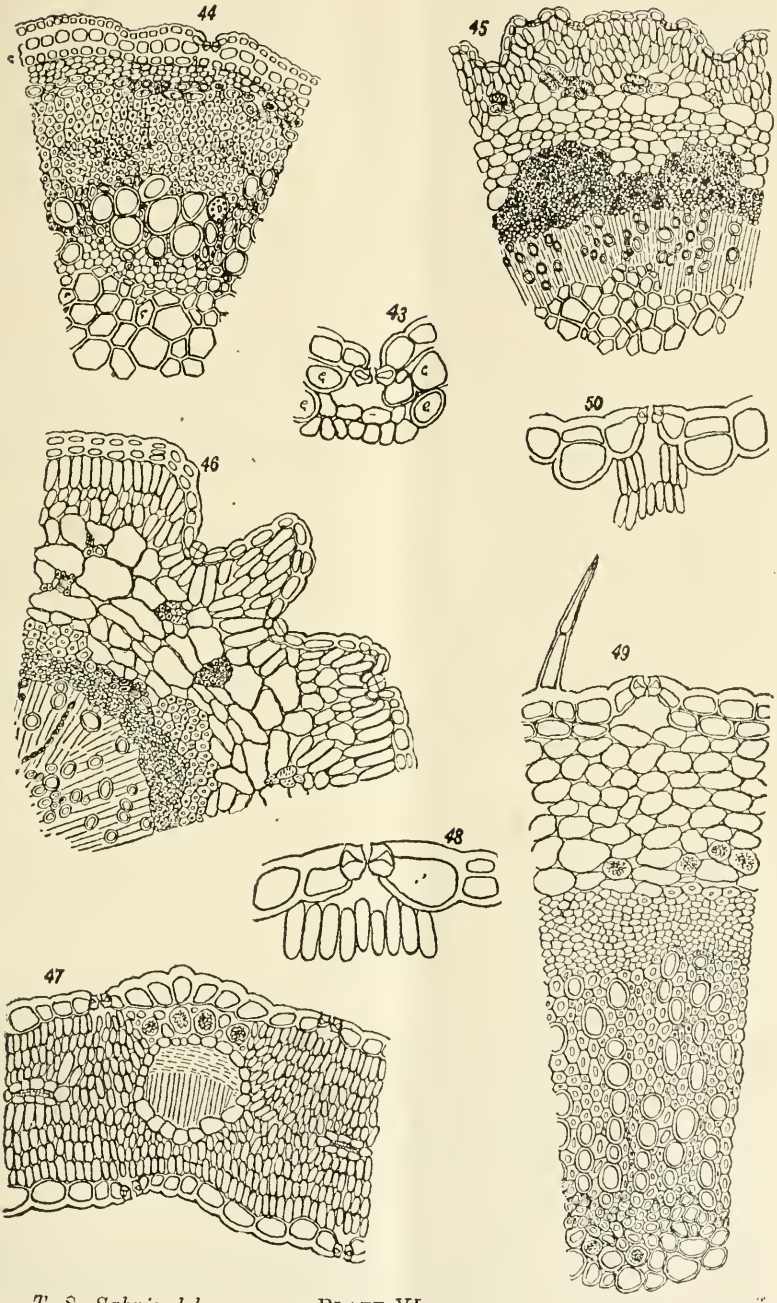
T. S. Sabnis del.

PLATE V.

Plate VI.

43-44 *Polycarpæa corymbosa.*
43 Stoma in the T. S. of the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.
44 T. S. of the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.
45 *Tamarix dioica.*
T. S. of the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.
46 *Tamarix articulata.*
T. S. of the axis.
Oc. 6 Com.; Ob. 8 mm. Ap.
47-49 *Bergia ammanioides.*
47 T. S. of the leaf.
Oc. 3; Ob. C.
48 Stoma in the T. S. of the leaf.
Oc. 3; Ob. 3 mm. Ap.
49 T. S. of the axis.
Oc. 3; Ob. C.
50 *Bergia odorata.*
Stoma in the T. S. of the leaf.
Oc. 1; Ob. 3 mm. Ap.

N.B.—To get the original dimensions multiply by 1·7.



T. S. Sabnis del. PLATE VI.

CONTRIBUTIONS TOWARDS A FLORA OF BALUCHISTAN.

From materials supplied by Col. J. E. B. Hotson, I.A.R.O.

BY

E. BLATTER, S.J., PROF. F. HALLBERG AND C. MCCANN.

St. Xavier's Coll., Bombay.

(*Continued from last issue*)

Resedaceae—(*Cont.*)

RESEDA *L.*

Reseda pruinosa *Del. Fl. Eg. p. 15.* Loc.: Taloi Sunt, 11 miles N. of Pasni, about 50 ft. (no. M 43 B); near Manguli, 157 miles SSW of Kalat, about 2,450 ft. (no. 239). Fl. and fr. in Feb. 1918, Sept. 1917. *Vern. Name*: Mazardum.

Reseda Aucheri *Boiss. Diagn. ser. I, part I, p. 5.* Loc.: Gwambuk, about 60 miles S. by E. of Panjgur, about 2,700 ft. (no. 43C); hills S of Chambar (Kolwa), 26° 9′ N, 64° 42′ E, about 1,800—2,200 ft. (no. 43D). Fl. in April 1918. *Vern. Name*: Mazardum.

OLIGOMERIS *Cambess.*

Oligomeris glaucescens *Cambess. in Jacq. Voy. Bot. 23, t. 5.* Loc.: Kulbar valley, E. of Dagja, 62° 33′ E, 26° 15′ N, about 1,700 ft. (no. 110). Fl. and fr. in March 1918.

Cistaceae.

HELIANTHEMUM *Pers.*

Helianthemum Lippii *Pers. Syn. II, 78* var. **micranthum** *Boiss. Fl. Or. I, 443.* Loc.: Chhuttok, 90 miles S. of Kauat, 4,500 ft. (no. 169, 170). Fl. and fr. in Aug. 1917.

Polygalaceae.

POLYGALA *L.*

Polygala sibirica *L. Sp. Pl. 987.* Loc.: Rari Dan, 170 miles S. by W. of Kalat, 2,300 ft. (no. 283). Fl. and fr. in Sept. 1917. *Vern. Name*: Kaj (Mashna Kaj) (Brah.).

Polygala erioptera *DC. Prodr. I, 326.* Loc.: Wahir, 25 miles S. by W. of Khozdar, about 4,200 ft. (no. 365). Fl. and fr. in Sept. 1917. *Vern. Name*: Choghal (Brah.).

Caryopyllaceae.

DIANTHUS *L.*

Dianthus crinitus *Sm. Act. Soc. Linn. II, 300.* Loc.: Siman river, 15 miles SE of Khozdar, about 3,700 ft. (no. 359). Fl. in Sept. 1917. *Vern. Name*: Aghud? (Brah.).

Dianthus fimbriatus *MB. Taur. Cauc. I, 382.* Loc.: Harboi, 9,000 ft. (no. 43A); Surab, 28° 29′ N, 66° 16′ E about 5,700 ft. (M. 375). Fl. in June 1918, Aug 1917. Uses: Said to be eaten by hares. *Vern. Name*: Aghud (Br.).

SAPONARIA *L.*

Saponaria vaccaria *L. Sp. Pl. 585*, var. grandiflora *Fisch. in DC. Prodr. I, 365.* Loc.: Panjgur, about 3,100 ft. (no. M 144, M 144A). Fl. and fr. in March 1918. *Vern. Name*: Karari (Br.).

SILENE *L.*

Silene conoidea *L. Sp. Pl. 598.* Loc.: Khudabadan, ¼ mile N. of Panjgur, about 3,100 ft. (no. M 178). Fl. in March 1918.

ARENARIA *L.*

Arenaria filiformis *Labill. Dec. IV, 408.* Loc.: Nagak (W. Kolwa), about 87 miles E. by N. of Turbat, about 2,400 ft. (no. M 185A). Fl. and fr. in April 1918. *Vern. Name*: Dandalo (Bal.).

Arenaria sp. (*Near* A. holosteoides). Loc.: Khudabadam, ¼ mile N. of Panjgur, about 3,100 ft. (no. M 183). Fl. in March 1918. *Vern. Name*: Baliko (Bal). Name uncertain.

SPERGULARIA *Pers.*

Spergularia diandra *Boiss. Fl. Or. I, 733.* Loc.: Khudabadan, ¼ mile N. of Panjgur, about 3,100 ft. (no. M 185). Fl. and fr. in. March 1918. *Vern. Name*: Dandalo (Bal.).

Spergularia marginata *Boiss. Fl. Or. I, 733.* Loc.: Near Sitani, 59 miles S. of Kalat, 5,300 ft. (no. 128); Mazarjuh, about 28° 11′ N, 66° 2′ E, about 5,200 ft. (no. M 365). Fl. and fr. in June and Aug. 1918. *Vern. Name*: Makankur (Br.).

Portulacaceae.

PORTULACA *L.*

Portulaca oleracea *L. Sp. Pl. 638.* Loc.: W. side of Burida Pass, 140 miles SSW of Kalat, under 4,250 ft. (no. 250), ; Garrok, 27 miles N. of Ornach, about 3,400 ft. (no. 276A); Shahdadzai, 72 miles S. of Kalat, 5,100 ft. (no. 138); Panchgur (no. M 327); Quetta; Korak (Pelar), 180 miles S. by W. of Kalat, 1,900 ft. (no. 276). Fl. and fr. in May 1918, July 1918, Aug. 1917, Sept, 1917. *Vern. Names*: Pichali, Pechali, (Bal. and Brah.), Mugher (Brah.). Uses: Cooked and eaten as a vegetable.

Tamaricaceae.

TAMARIX *L.*

Tamarix Pallasii *Desv. Ann. Sc. Nat. IV. 349.* Loc.: Siman river, about 15 miles SE of Khozoar, about 3,700 ft. (no. 361). Fl. in Sept. 1917. *Vern. Name*: Siah Gaz (Bal. Br.), Mauna Kiri (Br.).

Tamarix laxa *Willd. Act. Acad. Berol. (1812) 82.* Loc.: Awaran (Kolwa) 26° 24′ N, 65° 12′ E, about 1,750 ft. (M 12B); Dokob, 60 miles W. of Turbat, about 700 ft. (no. M 12); Teghab, 107 miles S. of Kalat, 4,150 ft. (no. 147A); Shahdzai, 72 miles S. of Kalat, 5,100 ft. (no. 147). Fl. and fr. in Aug. 1917, Sept. 1917, Dec 1917.

Vern. Names: Gaz (Bal. Br.), Shingir Gaz (Bal.), Shingir Kiri (Br.). "The names of the tamarisks are rather confused. This variety is called Shingir in Kech and by the Brahuis. It is called Soren (= red) by many Baluchis." (Hotson).

Tamarix articulata *Vahl Symb. II, 48, tab. 32.* Loc.: Awaran (Kolwa), 26° 24′ N. 65° 12′ E, about 1,750 ft. (no. M 14A); Dokop, 60 miles W. of Turbat, about 1,700 ft. (no. M 14); Teghab, 107 miles S. of Kalat, 4150 ft. (no. 117A). Fl. in August 1917, said to flower in spring. *Vern. Names*: Guh Gaz (Bal.), Sakori Gaz (Kiri). Kolwa is the Kech name for this tamarisk. About Mand it is called Guh, the name given in Kech to the Padha Gaz (Hotson). See the next species.

Tamarix stricta *Boiss. Diagn. ser. II, II, 57.* Loc.: Siman river, 15 miles SE of Khozdar, about 3,700 ft. (no. 362); Lukh, 100 miles S. of Kalat, 4,300 ft. (no.177); Dokop, 60 miles W. of Turbat, about 700 ft. (no. M 13, M 13A). Fr. in Aug. 1917, Sept. 1917, Dec. 1917. Vern. Names: Sor Gaz (Bal. Br.), Khisun Kiri (Br.), Sakori Gaz, Sakori Kiri (Bal. Br.), Padha Gaz (Bal.).—This tamarisk is commonly called Padha, but in some parts also Guh Gaz the latter being the Kech name for it. (Hotson).

Tamarix passerinoides *Del. Eg. III. no. 352.* Loc.: Quetta. Fl. in July 1918.

Tamarix longe pedunculata *Blatt. and Hall. spec. nov.* Frutex (vel arbor?) glaber, glaucus, dioicus. Folia vaginantia, subhorizontaliter truncata, abrupte deltoideo-mucronata vel cuspidata, in ramis novellis apice patentia, in ceteris adpressa. Racemi racemoso—paniculati, longe pedunculati, elongati, densissimi, ca 5½ cm longi, pedunculo ca. 13 cm longo. Bracteae triangulari-ovatae, acuminatae, floribus sessilibus sub-breviores. Sepala 5, rotundato-obovata, obtusa, duo lateralia carinata, omnia margine scariosa. Petala 5 purpurea ca. duplo calyce longiora, obovato-suborbiculata. Stamina 5, disco 5-glanduloso inserta; antherae apiculatae. Ovarium nullum. Flores femineos non vidimus. This species comes near T. dioica, but differs in the following points: The peduncle is much longer, the petals are obovate suborbicular, not linear-oblong. Loc.: Gajar, 165 miles SSW of Kalat, 3,450 ft. (no. 228). Fl. in Sept. 1917. *Vern. Name*: Gaz (Bal.).

Reaumuria *L.*

Reaumuria palaestina *Boiss. Diagn. ser. I. I. p. 10* **var. acuminata** *var. nov.* Differt a typo ramis glabris, foliis acutis, calycis laciniis acuminatis apice coriaceis, petalis calyce aliquantulum longioribus. Loc.: Garrok, 27½ miles N. of Ornach, about 3,400 ft. (no. 327). Fl. in Sept. 1917.

Reaumuria Stocksii *Boiss. Fl. Or. I, 761.* Loc.: Manguli, 26° 45′ N, 65° 21′ E, about 2,600 ft. (no. M 290; 290A; Zaham, about 42 miles S. of Panjgur, about 2,800 ft. (no. M 205); near Sitani, 59 miles S. of Kalat, 5,300 ft. (136), Panjgur, about 3,100 ft. (no. 141). Korak (Pelar), 180 miles S. by W. of Kalat, 1,900 ft. (no. 274). Fl; and fr. in March and April 1918. *Vern. Name*: Kuhi Drah Chok

(Bal.), Molido (Bal.), Sor (Br.), Simsur (Bal. Br.). Flowers rose-purple or pink.

Reaumuria hypericoides *Willd. Sp. II. 1250.* Loc.: Shireza Patk (Kharan), 27° 46′ N, 65° 37′ E, about 4,900 ft. (no. M 32 C); Kuchkan, about 17 miles SSW of Panjgur, about 2,900 ft. (no. M 139, M 139A); Garrok, 27 miles N. of Ornach, about 3,400 ft. (no. 327); Mitasing, about 17 miles ESE of Panjgur, about 4,000 ft. (no. 27 D). Fl. in March and April 1918. Fr. in March 1918, June 1918, Sept. 1917. *Vern. Names*: Kohalok (Bal.), Sorag, Sorago (Bal. Br.). The flowers are pink.

Reaumuria panjgurica *Blatt. & Hall. spec. nov.* (*Prope* R. Billardieri *J. & S.*) Frutex humilis, ramosissimus a basi, glaucus, glaberrimus ca 25 cm. altus. Cortex radicis necnon ramorum veterum brunneum, exfolians, ramorum juniorum albidum, scabrido-muriculatum. Folia ca. 10 mm longa, 5 mm lata, plana, coriacea, obovato-elliptica vel oblonga, vel linearia-oblonga vel subspathulata, apice generatim rotundato-obtusa, superiora interdum apice subacuta. Flores laxe paniculati, in axillis solitarii ramos breves terminantes. Rami florales interdum foliis parvis linearibus vestiti. Bracteae calyce multo longiores, lineares-spathulatae, subobtusae. Calyx 5-partitus ad medium, subcampanulatus, lobis ovatis-subacutis (non acuminatis), basi subcordatis, coriaceis, anguste scariosis margine. Petala calyce plus duplo longiora, lanceolata-subulata, 10 mm longa, 3 mm lata, basi utrinque squama triangulari-oblonga semiadnata, margine superiore fimbriato. Stamina numerosa in phalanges 5 petalis oppositas basi connata. Capsula coriacea valvis 5 oblongo-acuminatis, multinerviis, 8 mm longis, 2 mm latis. Semina pauca, undique longe-pilosa, pilis seminibus longioribus. Loc.: Panjgur, about 8,500 ft. (no. 321), growing on dry ground. Fl. and fr. in May 1918.

Malvaceae.

Malva *L.*

Malva rotundifolia *L. Sp. Pl. (1753) 688.* Loc.: Kalat, about 6,350 ft. (no. M 134 B); spring on Harboi, 19 miles ESE of Kalat, 8,800 ft. (no. 78); near Bazdad, 25 miles E. of Chambar (Kolwa), about 1,850 ft. (no. M 134 B); Kochau 122 miles SSW of Kalat 4,175 ft. (no. 78A). Fl. and fr. in March 1918, July 1918. Uses: Ground up, soaked in water, mixed with sweetmeat and drunk. At once relieves retention of urine. Of the fruit an ointment is made for the chest in cases of "dik", a dangerous illness. *Vern. Names*: Utper (Br.), Gwarag Pad (Bal.), Pochako.

Althaea *L.*

Althaea Ludwigii *L. Mantiss. (1767) 98.* Loc.: Mohtaji Kand, about 22 miles SW of Panjgur, about 2,800 ft. (no. M 134, M 138); Harbud, about 55 miles E. of Panjgur about 3,750 ft. (no. M. 311, M 311 A). Fl. and fr. in March and April 1918. *Vern. Names*: Utper (= camel's foot) (Br.), Pochako (Panjguri Bal.) Gwarag Pad (= crow's foot) (Kechi Bal.), Nampacho (Panjguri Bal.), Baharo (Bal.),

SIDA *L.*

Sida grewioides *Guill. & A. Rich. Fl. Seneg. I (1830) 71.* Loc.: Naka Khari (Las Bela), 33 miles from Karachi, about 100 ft. (no. 401). Fl. and fr. in Oct. 1917.

ABUTILON *Gaertn.*

Abutilon indicum *Sw. Hort. Brit. I (1827) 54.* Loc.: Jaur, 34 miles S. by W. of Khozdar, about 4,300 ft. about (no. 372, 372 A). Fl. and fr, in Oct. 1917. Uses: Said to be useless and not eaten by any animals. Also said to be bad for the eyes, and therefore called Baibaro, though how it should get near the eyes I could not understand. (Hotson). *Vern. Name*: Gogharo (Br.).

Abutilon bidentatum *A. Rich. Fl. Abyss. I (1847) 68.* Loc.: Rar Kaur, 165 miles S. by W. of Kalat, about 3,500 ft. (no. 293, 293 B). Fl. and fr. in Sept. 1917. *Vern. Name*: Kapochisk (Br. Bal.).

Abutilon muticum *Sw. Hort. Brit. ed. 2 (1830) 65.* Loc.: Rar Kaur, 165 miles S. by W. of Kalat, about 3,500 ft. (no. 293 A). Fl. in Sept. 1917.

Abutilon fruticosum *Guill. Perr. and A. Rich. Fl. Seneg. I (1830) 70.* Loc.: Hills near Ispikan, about 20 miles NE of Mand, about 1,200-1,500 ft. (no. M 98); Burida Pass, 140 miles SSW of Kalat, up to 4,250 ft. (no. 214). Fl. and fr. in March 1918, August, 1917. *Vern. Name*: Gulkhand (Br.).

PAVONIA *Cav.*

Pavonia arabica *Steud. Nom. ed. 2, II (1841) 279.* Loc.: Naka Kharri (Las Bela), 33 miles from Karachi, about 100 ft. (no. 140). Fl. and fr. in Oct. 1917.

HIBISCUS *L.*

Hibiscus trionum *L. Sp. Pl. (1753) 697.* Loc.: Quetta; Khozdar, 27° 48′ N, 66° 37′ E, about 4,100 ft. (no. 348); Kalat, 7,000 ft. (no. 5); Kalat, about 6,350 ft. (no. M 398); Surab, 43 miles S. of Kalat, 5,750 ft. (no. 107). Fl. in July 1918, Aug. and Sept. 1917.—Fr. in Aug. 1917, Sept. 1917. Uses. The leaves when very small are cut off and boiled, and after some preparation eaten with bread. Those leaves are called Garbust. *Vern. Names*: Pihu Pulli (Br.). Lasura (Br.).

Hibiscus micranthus *L. f. Suppl. (1781) 308.* Loc.: Near Manguli, 157 miles SSW of Kalat, about 2,450 ft. (no. 238); near Korak (Pelar), 180 miles S. by W. of Kalat, 1,900 ft. (280); hills S. of Chambar (Kolwa), 26° 9′ N, 64° 42′ E, about 2,150 ft. (no. M 25 B); hills near Ispikan, about 20 miles NE of Mand, about, 1,200-1,500 ft. Fl. and fr. in March and April 1918. *Vern. Name*: Zwangir.

Hibiscus pungens *Roxb. Hort. Beng. 50.* Loc.: Near Ornach, about 3,050 ft. (no. 321, 321 A). Fl. and fr. in Sept. 1917. *Vern. Name*: Mirani, Danku.

Tiliaceae.

GREWIA *L.*

Grewia tenax *Fiori Bosc. Piant. legn. Eritrea (1909) 246*—(G. populifolia *Vahl*). Loc.: Hushtar Rahi, 160 miles S. of Kalat, about

3,700 ft. (no. 280 A, B,); near Kanoji, about 47 miles N. of Las Bela on the road to Wad, about 3,200 ft. (no. 280 C); near Bazdad, 25 miles E. of Chambar (Kolwa), about 1,850 ft. (no. 36 E), Karochi darkaf, 60 miles NE of Pasni, about 1,350 ft. (no. M 36); hills near Ispikan, 20 miles NE of Mand, 1,200 to 1,500 ft. (no. M 36 A); near Chambar (no. M 36 B). Fl. in March 1918, Sept. 1917.—Fr. in Feb. 1918, Sept. 1917. Oct. 1917. Uses: The berries make a medicine for colds. Used as medicine for all sorts of diseases and very highly esteemed. (Hotson.) *Vern. Names*: Gwangir (Br. Bal.), Putrunk (Mandi Bal.). The Baluchis call this Buzi Putrunk (= goat's putrunk), to distinguish it from the next.

Grewia villosa *Willd. in Ges. Naturf. Fr. Neue Schr. IV (1803) 205.* Loc.: Hills near Ispikan, about 20 miles NE of Mand, about 1,200—1,500 ft. (no. M 84); hills S. of Chambar (Kolwa), 26° 9′ N. 64° 42′ E., about 2,000—2,200 ft. (no. M 262). *Vern. Name*: This is called Pachini (ibex) putrunk to distinguish it from the Buzi (or she-ibex) putrunk.

Corchors *L.*

Corchorus antichorus *Raeusch Nom. ed. 3 (1797) 158.* Loc.: Pirandar, 205 miles SSW of Kalat, about 1,900 ft. (no. 260); Zahren Kahur, 16 miles N. of Pasni, about 200 ft. (no. M 41). Fl. in Sept. 1917.—Fr. in Feb. 1918, Sept. 1917. Uses: A cooling drink is made from the leaves. *Vern. Name*: Munderi (Bal. Sindhi).

Zygophyllaceae.

Tribulus *L.*

Tribulus terrestris *L. Sp. Pl. 554.* Loc.: Shahdazai, 72 miles S. of Kalat, 5,700 ft. (no. 142); Garrok, 27 miles N. of Ornach, about 3,400 ft. (no. 325); near Manguli, 197 miles SSW of Kalat, about 2,450 ft. (no. 244). Fl. and fr. in Aug. and Sept. 1917. *Vern. Name*: Gurgunduk (Br.), Surinchk.

Tribulus alatus *Del. Eg. Ill. no. 438.* Loc.: Rek Chah, 11 miles E. of Chambar (Kolwa), about 1,800 ft. (no. M 269). Fl. and fr. in April 1918. *Vern. Name*: Kahurkah (Bal.).

Fagonia *L.*

Fagonia Bruguieri *DC. Prodr. I, 704.* Loc.: Quetta; Zahren Kahur, 16 miles N. of Pasni, about 200 feet (no. M 8B). Fl. and fr. July 1918. *Vern. Name*: Karkawag (Bal.).

Fagonia myriacantha *Boiss. Diagn. ser. I, VIII, 123.* Loc.: Baran Lak, 28 miles S. of Wad, about 3,900 ft. (no. 237A). Fl. and fr. Oct. 1917. *Vern. Name*: Karkawag (Br. Bal.). Note: Flowers rather a deeper mauve than usual. They vary from pale mauve to practically white.

Fagonia Olivieri *DC. Prodr. I, 704.* Loc.: Near Manguli, 197 miles SSW of Kalat, about 2,450 ft. (no. 237); Dokop, 60 miles W. of Turbat, about 700 ft. (no. M 8, M 8 A). Fl. in Sept. 1917, Dec. 1917.—Fr. in Sept. 1917. *Vern. Names*: Karkavag (Br. Bal.)

Fagonia spinosissima *Blatt. & Hall. spec. nov.* Frutex a basi ramosissimus, caulibus procumbentibus, veteribus teretibus albidis,

novellis viridibus-glaucis, minutissime et breviter glandulosis, subtetragonis sulcatis. Internodia elongata, 10-20 mm longa. Spinae folia excedentes, 25 mm attingentes, patentes, acerosae, elegantes. Folia elliptica vel elliptico-oblonga, unifoliolata, maxima 15 mm longa et 6 mm lata, spinuloso-mucronata, glanduloso-puberula, nervis obscuris, margine aliquantulum incurvata, petiolata, petiolo 4 mm attingente. Sepala lanceolata vel ovato-lanceolata, acuminata, glanduloso-puberula. Petala non vidimus. Pedunculus recurvus variabilis, generatim capsulae aequilongus, glanduloso-puberulus. Capsula duplo latior quam longa, profunde 5-loba, depressa, acuta, velutina et glanduloso-puberula. Stylus persistens, capsulae aequilongus vel brevior. Semina ovoidea, valde compressa, foveolata-punctata. (Sub microscopio glandulae minutissimae nitentes unamquamque foveolam circumdantes conspici possunt). Differt a Fagonia Olivieri glandulis non sessilibus, spinis folia multum superantibus, forma foliorum et sepalorum, foliis longe-petiolatis. Loc. : Panjguri (no. M 8 E). Fr. in May 1918. *Vern. Name* : Karkawag (Bal.).

Fagonia arabica *L. Sp. Pl. 553.* Loc. : Manter Juzhaf, about 40 miles S. of Panjgur, about 3,200 ft. (no. M 203). Fr. in April 1918. Uses : The roots and thicker parts of the stems of this plant are said to be good for coughs. They are either chewed raw, or boiled in water and the water drunk. I chewed a piece of root and found it strongly astringent, and the taste very lasting. It is said that large quantities of the roots are exported from this neighbourhood to Sind and other countries. (Hotson.) *Vern. Name* : Shurdo, or Shordu (Bal.).

Fagonia sp. *Prope* F. thebaicam *Boiss.* Loc. : Harboi, 18 miles ESE of Kalat, 9,000 ft. (no. 73) ; under Harboi, 16 miles ESE of Kalat, 8,400 ft. (no. 45). Grows in thick clusters. *Vern. Name* : Chunak gird pith.

ZYGOPHYLLUM *L.*

Zygophyllum eurypterum *Boiss. & Buhse Aufz. 49.* Loc. : Kuchkan, about 17 miles WSW of Panjgur, about 2,900 ft. (no. M 135) ; Kalgali Kaur, N. of Zayaki Jangal, about 4,800 ft., one of the commonest plants (no. M 135 C) ; Shahdadzai, 72 miles S. of Kalat, 5,100 ft., exceedingly common all over this country and Makran. Grows low and is so constantly grazed down by camels and other animals that it is very rare to find any leaves on it (no. 150). Fr. in March 1918. *Vern. Name* : Kirech, Alonj.

Zygophyllum trialatum *Blatt. & Hall. spec. nov.* Frutex, ramis albidis sulcatis, ad nodos incrassatis. Folia obovato-obtusa, interdum mucrone minutissimo, in petiolum attenuata, petiolo laminae tertiam partem attingente, 30 mm longa, 15 mm lata, juniora pubescentia, vetera glabra. Stipulae breviter triangulares, longe-cuspidatae. Flores axillares, solitarii. Pedunculi calyce 4-plo longiores, aliquantulum pubescentes, fructificantes ad apicem incrassati. Sepala 4, 5 mm longa, 2½ mm lata, oblonga, margine scariosa, apice obtusa vel retusa, in parte apicali tantum pubescentia. Squamae 4, oblonga, fimbriatae in parte dimidia superiore, ovario aequilongae. Petala sepalis duplo longiora flava, late elliptico-oblonga, obtusa, glabra.

Stamina 8, exserta. Stylus ovario duplo longior. Capsula trialata globosa, depressa, basi et apice retusa. Differt a Zygophyllo euryptero pedunculis longis, stipulis longe-cuspidatis, capsula trialata. Loc.: Quetta. Fl. and fr. in July 1918.

Zygophyllum simplex *L. Mant. 68* Loc.: Las Bela, about 700 ft. (no. 398). Fl. and fr. in Oct. 1917. *Vern. Name*: Fesul (Sindhi of Bela).

Zygophyllum fabago *L. Sp. Pl. 551.* Loc.: Quetta; Kulbar valley above Dagja, 62° 32′ E. 26° 15′ N. (no. M. 31 A.). Fl. in July 1918. *Vern. Name*: Shurdu (Bal.).

Zygophyllum coccineum *L. Sp. Pl. 551.* Loc.: Junction of Raghai and Sichk rivers (Kharan), about 3,600 ft. (no. M 31 C); Karochi Darkaf, about 60 miles N. by E. of Pasni, about 1,400 ft. (no. M. 31 A.); Turbat, about 600 ft. (no. M 3); Kaurdat 10 miles N. of Rekin, about 1,900 ft. (no. M. 31 B.); NE of Hoshap, about 60 miles ENE of Turbat, about 2,000 ft. (no. M 31); near Manguli, 197 miles SSW of Kalat (no. 234). Fl. in Feb. and April 1918. *Vern. Names*: Shurdu (Bal. Br.), Sohro (Bal.). Note: The leaves seem to vary a good deal. We note the following forms: (a) All leaves unifoliolate, leaflets cylindrical, one only clavate, shorter than the petiole, green; (b) All leaves unifoliolate, cylindrical, about as long as the petiole, reddish; (c) Leaves, 1-2-foliolate. Leaflets shorter than petiole, generally clavate; (d) Leaflets 1 or 2, of variable length, sub-cylindrical.

SEETZENIA *R. Br.*

Seetzenia orientalis *Dene. Fl. Sin. 56, tab. 7.* Loc.: Near Bazdad, 25 miles E. of Chambar (Kolwa), about 1,850 ft. (no. M 95 C). Fl. in April 1918. *Vern. Name*: Cheink (Bal.).

PEGANUM *L.*

Peganum harmala *L. Sp. Pl. 638.* Loc.: Kalat, 7,000 ft. (no. 2); Chahdadzai, 72 miles S. of Kalat, 5,100 ft. (no. 2 C); Quetta; Pirandar, 205 miles SSW of Kalat, about 1,900 ft.; Sarchib, about 62° 40′ E., 26° 16 N (no. M 119); Nag (W. Kolwa) about 83 miles E. by N. of Turbat, about 2,300 ft. (no. M 119 A); Zayaki Jangal, 27° 54′ N, 65° 51′ E, about 4,600 ft. (no. M 119 B); Sitani, 59 miles S. of Kalat, 5,300 ft. (no. 2 B). Fl. in April and July 1918, Sept. 1917.—Fr. in June 1918, Aug. 1917. Uses: The seeds are burnt on charcoal or coal, and their scent, which is pleasant, inhaled by people who are sick in any way. *Vern. Names*: Kisankur (Bal. Br.), Aspantan, Gandako (Bal.). The seeds are called "harmul".

Geraniaceae.

MONSONIA *L.*

Monsonia heliotropioides *Boiss. Fl. Or. I (1867) 897.* Loc.: Hushtar Rahi, 160 miles S. of Kalat, about 3,700 ft. (no. 303). Fl. in Sept. 1917. *Vern. Name*: Gudbaher (Br. Bal.).

ERODIUM *L'Herit.*

Erodium laciniatum *Cav. Diss. 228, tab. 113, fig. 3.* Loc.: Quetta. Fr. in July 1918.

(To be continued.)

CURRENT LITERATURE.

New Indian Species, etc.

Bonnaya bracteoides *Blatt. and Hall, Spec. Nov., Journ. Bomb. Nat. Hist. Soc. XXV (1918) 416.*

Bonnaya estaminodiosa *Blatt. and Hall, Spec. Nov., l. c. 416.*

Bonnaya quinqueloba *Blatt. and Hall, Spec. Nov., l. c. 417.*

Bonnaya micrantha *Blatt. and Hall, Spec. Nov., l. c. 417.*

Bonnaya veronicaefolia *Spreng.*, **Bonnaya grandiflora** *Spreng.*, and **Bonnaya verbenaefolia** *Spreng.* should be considered as distinct species according to Blatter and Hallberg, *l.c. 418-19.*

Ilysanthes hyssopioides *Benth*, and **Ilysanthes parviflora** *Benth.* According to Blatter and Hallberg (l. c. 419—20) their synonymy should be corrected as follows :—

Ilysanthes hyssopioides *Benth. in DC. Prodr. X, 419*—Gratiola hyssopioides *Benth Scroph. Ind. 34.*

Ilysanthes parviflora *Benth, in DC. Prodr. X, 417.*—Gratiola parviflora *Roxb. Cor. Pl. III, 3, t. 203; Fl, Ind. I, 104,*—Bonnaya hyssopioides *Wight Ic. t. 857.*—Bonnaya parviflora *Benth, Scroph. Ind. 34.*

Mazus McCannii *Blatt and Hall. Spec. Nov.*, Journ. Bomb. Nat. Hist. Soc. *XXV (1918) 423.*

Lindenbergia urticaefolia *Lehm.* to include L. polyantha *Royle*, according to Blatter and Hallberg, *l.c, 424.*

Rotala pentandra *Blatt. and Hall. Nov. Comb., l.c. 707.*

Rotala Fysonii *Blatt. and Hall, Spec. Nov.*

Rotala stipulata *Blatt. and Hall. Spec. Nov., l.c. 710.*

Rotala indica *Blatt. and Hall. Nov., Comb., l.c. 711.*

Rotala rotundifolia *Blatt. and Hall. Nov. Comb., l.c. 718.*

Ammannia desertorum *Blatt. and Hall. Spec. Nov., l.c. XXVI (1918) 213.*

Farsetia macrantha *Blatt. and Hall. Spec. Nov., l.c. 220.*

Melhania magnifolia *Blatt. and Hall. Spec. Nov., l.c. 228*

Zizyphus truncata *Blatt. and Hall. Spec. Nov., l.c. 234.*

Psoralea odorata *Blatt. and Hall. Spec. Nov., l.c, 238.*

Tephresia multiflora *Blatt. and Hall. Spec. Nov., l.c. 239.*

Tephrosia petrosa *Blatt. and Hall. Spec. Nov., l.c. 239.*

Rhynchosia rhombifolia *Blatt. and Hall. Spec. Nov., l.c. 242.*

Rhynchosia arenaria *Blatt. and Hall. Spec. Nov., l.c. 243.*

Euphorbia laeta *Heyne* and **E. oreophila** *Mig.* have been restituted by L. J. Sedgwick to their former rank of species in place of E. Rothiana *Spreng., l.c. 599.*

E. B.

The Flora of Persian Baluchistan and Makran.

Blatter, E, and Hallberg, F. : *Journal of the Bombay Natural History Society XXV 4.*

The Rev. E. Blatter, S.J., and Prof. F. Hallberg publish a list of the species collected in this area by Capt. I. G. B. Hotson, I.A.R.O. No analysis of the flora is given, but the list shows many genera of our drier districts, represented sometimes by the same species as in S. India, along with genera

of cooler climates. Among the latter are species of *Ranunculus*, *Fumaria*, *Lathyrus*, *Draba*, *Tamarix*, *Astragalus*, *Vicia*, *Prunus*, *Bupleurum*, *Carduus*, *Olea*, *Antirrhinum*, *Linaria*, *Plantago*, *Euphorbia*, *Salix*, *Populus*, and *Asphodelus*; many of them by the same species as occur in Europe. Among genera and species common in South India are *Cleome*, *Capparis*, including (*C. aphylla* Roth which occurs in Tinnevelly), *Tribulus*, *Citrus medica* (orange), *Gymnosporia montana* Benth., *Zizyphus jujuba* Lam., *Dodonœa viscosa* L., *Desmodium*, *Terminalia Catappa* L., *Eugenia jambolana* Lam., *Launœa*, *Tylophora*, *Cordia myxa* L., *Heliotropium*, *Trichodesma*, *Solanum nigrum* L., *Sesamum indicum* D.C., *Ocimum basilicum* L., *Ærua lanata* Juss., *Aristida*, and several others. Many of the common species are no doubt cultivated, for the sake of their edible fruits or their use for pot-herbs; but apart from them it is clear that, though the species are different, there is a good deal of affinity in the genera, between the Persian Baluchistan and the drier parts of the Carnatic. The temperate genera and species, it will be noticed, are mostly herbs and without doubt belong to the cool winter months.

P. F. F.

Flora of Northern Gujarat.

W. T. Saxton, M.A., F.L.S., I.E.S., I.A.R.O., and L. J. Sedgwick, B.A., F.L.S., I.C.S., Plants of Northern Guzarat.—*Records of the Botanical Survey of India, Vol. VI, No. 7.*

Though published in 1918, this monograph was written in 1914-15. As the authors explain, it deals with only a small fraction of Northern Gujarat, namely, the immediate neighbourhood of Ahmedabad, and the taluks of Prantij and Modasa, which lie to the north-east of that city. These taluks touch the fringe of the great Malwa forest region. Kharagoda on the Rann of Cutch has been included on the strength of one visit, and this has resulted in the inclusion of some of the halophytes of the Rann, with the inevitable omission of others, and excludes the possibility of a full discussion of the flora of that interesting region.

The work is divided into three parts, viz., Part I—Descriptive and Analytical, Part II—Œcology, and Part III—Flora. As described in the first part the area worked includes the pure sand tracts round Ahmedabad, some black soil tracts in Modasa, and the stony hills near Modasa where the Malwa forests begin. The main interest of this part of the work is that it brings out how the Perso-Arabian flora and the Indo-Malayan flora meet in Gujarat. On the whole the character of the flora of the sand tracts is essentially Perso-Arabian. The Perso-Arabian plants mentioned on page 216 are, as the floral part shows, denizens of the sand region; while the Indo-Malayan plants listed on the same page are similarly seen to be mainly denizens of the Malwa forest system. The line dividing the two great floras is, therefore, fairly definite, and could be ultimately plotted on a floral map of Asia. Apart from the presence of Perso-Arabian plants the total absence of many of the important Indo-Malayan families and genera is significant. For instance, there is not a single Orchid, Aroid, Amaryllid or Ginger, nor any species of Strobilanthes, Dalbergia, Hedyotis, Anotis, Flemingia, Smithia, Impatiens, Arundinella and a host of other typically Indo-Malayan genera. The flora is essentially a xerophytic one, with the addition of an important swamp flora typical of Indian marshes and tanks. In fact this swamp-flora and a handful

of trees confined to the Malwa region are the only links with Indo-Malaya. A noteworthy feature is the abundance of Gramineæ and Cyperaceæ, which together total 148 out of the 614 species.

This work adds twenty-two truly wild and three alien species to the Bombay flora, and establishes as genuine indigenous species ten which are excluded in Cooke's work. Thus thirty-five species may be said to have been added to the flora. In addition to this our knowledge of distribution of other species within the Presidency has been materially advanced.

Part II deals with the œcology of the district. The authors have accepted Warming's analysis of the world's flora as a basis upon which to work, and have considered that the great bulk of the area discussed belongs to his class 10, Psilophytes. In Warming's use of the word this term is equivalent to savannah. The woodland savannah consists of the Teak *Tectona grandis*. Bael *Aegle marmelos*, *Morinda citrifolia*, *Odina wodier* and other trees familiar to botanists on the other, eastern, side of India, along with shrubs like *Helicteres isora*, *Carissa carandas*, *Holarrhena antidysenterica* and *Nyctanthes arbor-tristis*. The 'thorn-savannah' in the same way consists largely of *Zizyphus œnoplia*, *Z. jujuba*, *Gymnosporia montana*, *Cassia auriculata*, *Capparis sepiaria* and others, all common enough on the dry hills of S. India.

As regards other associations, the flora of open sheets of water such as 'tanks,' and the slow moving rivers (Hydrophytes), and also that of their banks (Helophytes) are both very similar to those of similar situations in the Carnatic—*Nymphœa lotus*, *Hydrilla verticillata*, *Trapa bispinosa*, *Jussiœa repens* and *Nitella sp.* in the water: *Herpestis Monniera*, *Lippia nodiflora* and *Marsilia quadrifoliata* on their banks, to mention only a few. The dried mud such as one finds in dried tanks also bears very similar vegetation to that of Madras—the Babul *Acacia arabica* being abundant, and prostrate herbs like *Coldenia procumbens*, *Chrozophora plicata*, *Mollugo hirta* and *Polygonum plebejum*. The Mesophytic flora is, on account of the general dryness of the country, distinctly poor; and only two examples are noted by the authors where the ground was kept permanently moist, one by a tank, the other by a spring. Nearly all the plants given are such as occur in similar places in South India.

The authors have added some notes on the associations of cultivated lands, with a list of the common weeds and hedge-plants. In North Gujarat the hedge is a much more important feature than in other parts of India and harbours a definite and not uninteresting flora. Their list comprises the trees and other woody plants, the climbers, and the small herbs: and they distinguish them according to the degree of commonness or rarity, and the climbers according also to their habit of the roots or lower portions.

This œcological part is, perhaps, the first instance of such work in India, and the example will, it is to be hoped, be followed in other parts of this country.

Histology.

Beer, R., and Arber, Agnes. On the occurrence of Multinucleate Cells in Vegetative Tissues. *Proc. Roy. Soc. B. 91; B. 635 p. 1.* (*Aug. 1919*)

That multinucleate cells occur occasionally in plants has been known ever since the days of Naegeli, but chiefly in connection with specialised

tissues or cells, as embyro sacs, tapetal cells, pollen tubes, etc. In 1915 Miss Pramkherd drew attention to the frequent occurrence of such cells in different tissues of young organs of widely different but by no means specialised character. Among ferns they were found in the petiole and sporangiophore; among phanerogams in petiole, hypocotyl, coleoptile, stem, inflorescence axis, plumule bud and peduncle. They tend to occur in regions of activity and rapid elongation, and are due, she supposed, chiefly to amitotic division, and being probably followed by wall-formation, might contribute to the rapid formation of the tissue. Rudolf Beer and Agnes Arber in the paper now under notice, record the occurrence of binucleate and multinucleate cells in vegetative tissues of 177 species representing 60 families, most frequently in the stem but also in roots, and always characteristic of young actively growing tissues. In opposition to the majority of observers they consider that the division of the nucleus has always been a mitotic one, no single instance of direct division having been observed. A peculiarity in the development of the binucleate condition is the formation of what the authors propose to call the *Phragmosphere*. After the spindle plate has made its appearance it is apparently resorbed, and the whole phragmoplast with its associated cytoplasm becomes transformed into a hollow sphere which encloses the two nuclei and ultimately becomes co-extensive with the cytoplasm lining the cell-wall.

The fate of the nuclei varies: in some cases they persist, even, as in the cortex of *Rosa*, for two years. In some they soon degenerate, but there is no evidence of fusion.

From the frequency of the occurrence of bi-nucleate and multinucleate cells in growing tissues the authors regard them as a normal feature, a definite phase in the growth of the higher plants.

This phase usually succeeds the meristematic stage and preceeds the period of maximum growth and may therefore be considered as due to a loss by the cytoplasm of the power to divide, while the nucleus is still capable of doing so. The authors are inclined to think that the diffusion into the cytoplasm of the nuclear material both at each division (because of the solution of the nuclear-membrane) and on the disintegration of the nuclei, may contribute to the cytoplasm and affect its activities.

P. F. F.

Hepaticae.

Campbell D. H. Studies on some East Indian Hepaticae. *Annals of Botany Vol. XXII. No. CXXVII. July 1918.*

The writer describes the structure and development of some species of *Dumortiera* and gives the description of a new monœcious species of the genus from Borneo characterised by the formation of several (5-6) sessile successive male and female receptacles on a series of terminal adventitious shoots. The stucture of *Wiesnerella denudata* (Mitten) St, is also described. The author concludes that *D. velutina* shows the least reduction, for not only are the outlines of the air-chambers quite evident, but the characteristic assimilative tissue is present in the form of very numerous superficial papillate cells. In *D. trichocephalla*, which is more strongly hygrophilous in habit, the reduction of the air-chambers is much more complete, and in a third species, from Hawaii, probably *D. hirsuta*, the suppression is complete.

Wiesnerella is said to be closely related to *Dumortiera* on the one hand, while on the other it is connected with the typical *Marchantiaceae*. About the only evidence of reduction in *Wiesnerella* is the character of the stomata especially on the receptacles. According to the writer it connects forms of the type *Marchantia* with the reduced *Dumortiera*. In the reviewer's opinion we might even go further and say that on the *Marchantia* side it is related to *Fegatella conica* which occurs in similar moist places—in fact the two were collected by him from the same locality growing side by side on the road from Dalhousie to Khajiar in the western Himalayas.

Graham, Margaret. Centrosomes in Fertilisation stages of *Preissia commutata* (Scop) Nees. *Annals of Botany Vol. XXII. No. CXXVII. July 1918.*

The writer has studied the process of fertilisation in *Preissia commutata* at a stage when the uncleus of the antherozoid lies near the centre of the egg. The conclusion is that centrosomes as definite granular bodies are present in the fertilised egg at the time when the nuclei are paired, just as they are present in the divisions proceeding spermatogenesis and as blepharoplasts during metamorphosis.

Cribbs, J. E., A Columella in Marchantia polymorpha. *Botanical Gazette. Vol. 65 No. 1 Jan. 1918.*

Cases are described and figured in which elaters were found aggregated in the centre of the capsule forming a sort of columella instead of being scattered throughout the cavity which is the usual mode of their occurrence. Some of the sporogenous cells intermingled with the elaters near the centre are disorganised in the course of development. A columella of this type is said to strongly suggest the elaterophore of *Pellia*. The cap of sterile cells at the tip of the capsule occasionally consisting of three or four layers of cells is also described. Both these features are very interesting as they bring the structure of the capsule of *Marchantia* into line with the other liverworts in which these characters are met with.

Haupt, A. W., A Morphological Study of Pallavicinia Lyellii. *Botanical Gazette. Vol. LXVI No. 6 December 1918.*

The structure and development of the thallus, sex organ and the sporogonium is described. The branching of the thallus which consists of a single prostrate portion is both apical and adventitious. It is dioecious. The antheridia occur in two rows on each side of the midrib, and each is protected from behind by an involucral upgrowth. The archegonia are in dorsal groups sorrounded by an involucre and a perianth. The lower half of the fertilised egg becomes a haustorial organ and contributes nothing to the development of the foot, seta or capsule. The calyptra is 4 or 5 cells in thickness. The differentiation of the spores and elaters follows the mothod of *Symphyogyna*. A sterile cap is present at the apex of the capsule and remains intact in dehiscence which takes place by means of four longitudinal slits.

S. R. KASHYAP.

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All matter for the printer should be typed and on one side of the paper only. The name of a genus should begin with a capital letter, but that of the species only when it is adapted from a proper name (Vienna Rules). No comma should be put in after the specific name and before that of the founder of the species. The Editor will see to the type but the writer may, if he likes, indicate it on the following lines. The name of a plant at the opening of a paragraph or when it is desired to direct special emphasis to it may be underlined wavy (~~~~~~~~~~) for printing in **antique** type, with the founder's initial or name underlined plain ———) for *italics*; thus **Acalypha indica** *L.* If in the middle of a paragraph the name should be underlined plain, but the founder's initial not, thus *Acalypha indica* Linn.

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THE PHYSIOLOGICAL ANATOMY OF THE PLANTS OF THE INDIAN DESERT

BY

T. S. SABNIS, B.A., B.Sc.

St. Xavier's College, Bombay.

(*Continued from last issue.*)

Portulaca quadrifida, *L.*—(*Cont.*). The pith is composed of thin-walled cells filled with starch granules.

The two features, viz: the peripheral position of the aqueous tissue and the central position of the assimilatory tissue near the vascular bundles are quite significant. The acqueous tissue from its peripheral position is able to absorb moisture easily and carry on its function without being disturbed by any other tissue situated outside. It further protects the assimilatory tissue from the injurious effects of intense light and heat.

Were the assimilatory tissue peripheral, the products of assimilation would have to travel a long distance before they could reach the vascular bundles; thus the distribution of the products of assimilation would be greatly retarded. Therefore either the assimilatory tissue should be centrally placed near the vascular tissue or the aqueous tissue should be reduced, so that the distribution of the assimilatory products may go on rapidly.

It is possible that the assimilatory tissue enclosed by an extensive aqueous tissue may not get enough light, but this cannot be helped. As the development of an aqueous tissue is necessary for succulent plants, the central position for the assimilatory tissue is the only position, so that both the tissues can carry on their work without being interfered with by the other.

TAMARISCINEAE.

Tamarix dioica *Roxb.*—Pl. VI, fig. 45. Epidermal cells with inner walls a little more thickened than outer walls. Pits not deep. Cortical parenchyma of small cells. Sclerenchymatous pericycle more or less forming a loose ring of stone-cells with interposing cells thickened and radially striated. Wood forming a composite hollow cylinder. Soft bast forming groups. Medullary rays 2-6 seriate. Pith composed of thick-walled cells.

Tamarix orientalis *Forsk.*—Fig. 46. Epidermal cells with outer and inner walls thin. Pits quite deep. Cortical parenchyma formed of large thin-walled cells. Sclerenchymatous pericycle more or less isobilateral. Wood forming a composite central cylinder without a central pith tissue. Soft bast forming a continuous ring. Medullary rays uniseriate and few.

Structure of the Axis :—The epidermis consists of thin-walled horizontally tabular cells. The front cavity is depressed and closed above and below by thin walls, fig. 45. The guard-cells are in the plane of or in a plane lower than that of the surrounding cells.

Clothing hairs are not found on the axis of either of the species. External glands, figs. 45, 46, are placed in pits ; they form spherical structures divided by horizontal and vertical three-wall into four thin-walled cells, and are accompanied on their inner side by two depressed epidermal cells which form the subsidiary cells of the glands. The glands do not project above the surface; they secrete hygroscopic salts which fill the pits and absorb moisture from the air outside.

The primary cortex is characterised on its outer side by an assimilatory tissue of palisade cells and on its inner side by cortical colourless parenchyma. There are numerous water-storing tracheids in the cortical parenchyma with pitted or scalariform thickenings, the larger ones being accompanied by a few stone-cells. Cortical parenchyma forms an aqueous tissue and in *T. orientalis* is composed of large thin-walled cells.

The pericycle is composed of large groups of stone-cells. The stone-cell groups in *T. dioica* are closely placed all round the soft bast and the cells interposed between them are characterised by sclerosis and by radical striation of the wall. In *T. orientalis* stone-cell groups are placed on two opposite sides in the form of arcs and the cells interposed between them are thin-walled and parenchymatous. The sides possessing the stone-cell groups may perhaps represent the plane of the axis most affected by the wind ; and the stone-cell groups may have been developed in that plane to protect the axis against violent shaking by the wind.

The structure of the wood differs in the two species. In *T. orientalis* (fig. 46) the wood forms a composite solid central cylinder and is composed of numerous small vessels embedded in interfascicular wood prosenchyma. In *T. dioica* (fig. 45) the wood forms a composite hollow central cylinder enclosing a small pith tissue and consists of xylem bundles connected together by interfascicular wood prosenchyma. Medullary rays are 2-6 seriate in *T. dioica*. In *T. orientalis* they are uniseriate and few. The soft bast forms a continuous ring in *T. orientalis*, while in *T. dioica* it occurs in groups opposite the xylem bundles.

The pith of *T. dioica* is formed of thick-walled cells, those near the periphery being filled with granules; it does not occur in *T. orientalis*.

Internal secretory organs in both the species are represented by some of the cortical cells near the periphery with tanniniferous contents.

ELATINEAE.

Bergia ammanioides *Roxb.*—Pl. VI, figs. 47, 48, 49. A small number of cells with clustered crystals occurring near the veins. Secretory cells with tanniniferous contents found in the pith. Clothing hairs not found on the leaf. Hairs on the axis in the form of very thin-walled uniseriate trichomes. Glandular hairs absent on the leaf and axis. T. S. of the axis quadrangular. Assimilatory tissue in the axis formed of chloroqhyll containing parenchyma. Sclerenchymatous pericycle in the form of small stone-cells at the angles. Medullary rays absent.

Bergia odorata *Edgew.*—Pl. VI, fig. 50; Pl. VIII, figs. 51, 52. A layer of polygonal cells with clustered crystalsin the middle of the mesophyll. Numerous clustered crystals near the veins. Secretory cells with tanniniferous contents in the cortical parenchyma, soft bast and pith. Ordinary unicellular hairs and uniseriate trichomes found on the leaf and axis. Glandular shaggy hairs occurring on the leaf and axis. T. S. of the axis circular. Assimilatory tissue in the axis composed of short palisade cells. Sclerenchymatous pericycle forming a loose ring of small groups of stone-cells. Medullary rays 1-2 seriate.

Structure of the Leaf:—The epidermis is composed mostly of horizontally tabular cells with very large water-storing cells intercalated amongst them. The water-storing cells are sometimes divided by cross walls into unequal halves, the lower half being much larger than the upper one. The inner walls are thin and arched convexly inwards, so as to come into close contact with the assimilatory tissue below. The lateral walls are thin and straight; the outer walls are flat and greatly thickened.

Stomata occur on both the surfaces, being a little more numerous on the lower. Guard-cells are elevated above the plane of the surrounding cells and the front cavity is a little raised above the surface. Stomata are surrounded by 3-4 ordinary epidermal cells.

The mesophyll is composed of short palisade cells on either side without a middle tissue except for a layer of polygonal cells containing clustered crystals in the middle of the mesophyll in *B. odorata*.

Internal secretory cells are not found in the leaf. Oxalate of lime occurs in the form of numerous clustered crystals near the veins. In *B. odorata* there is a layer of polygonal cells with clustered crystals in the middle of the mesophyll (fig. 51). In the axis clustered crystals occur in the cortical parenchyma and pith. Veins are provided with sheaths of green thick-walled cells. Larger veins are vertically transcurrent above and below by colourless parenchyma.

Hairy covering on the leaf and axis consists of clothing and glandular hairs. Clothing hairs are partly unicellular and partly uniseriate trichomes. They are not found on the leaf of *B. ammanioides* and those on the axis are very thin-walled. Glandular hairs occur only in *B. odorata* and are of a shaggy type; they are composed of a multicellular stalk and of a multicellular head (figs. 51, 52).

Structure of the Axis:—The epidermis is two-layered. Outer epidermal cells have outer walls greatly thickened, the lateral walls being thin. The stomata are like those on the leaf and are surrounded by 4-5 ordinary epidermal cells. The primary cortex is characterised in its outer portion by an assimilatory tissue, which in *B. odorata* (fig. 52) is composed of short palisade cells and in *B. ammanioides* (fig. 66) of chlorenchyma. Inner portion of the cortex is formed of large-celled cortical parenchyma.

The wood in both the species presents a quadrangular appearance. It is broader at the angles and is much narrowed between. Interfascicular wood prosenchyma is extensive. The medullary rays occur in *B. odorata* and are 1-2 seriate. The vessels are arranged in rows. Wood parenchyma is scantly developed.

The pith is composed of thin-walled cells. Internal secretory organs are represented by secretory cells with tanniniferous contents. They occur in the cortical parenchyma in the soft bast and pith of *B. odorata* and only in the pith of *B. ammanioides*.

MALVACEAE

Sida grewioides *Guill.*—Figs. 53, 54. Woody. Stomata more numerous on the lower surface. Internal glands numerous in the mesophyll. Clustered crystals occurring near the veins of the leaf and in the soft bast of the axis. Clothing hairs tufted and more

numerous on the lower surface. Glandular hairs pitcher-shaped and more numerous on the lower surface. Cortex characterised by cork and collenchyma. Assimilatory tissue formed of chlorenchyma. Bast fibres occurring in the soft bast. Wood uniformly broad. Medullary rays uniseriate. Pith formed of thin-walled cells.

Abutilon fruticosum *Guill.*—Figs. 55, 56. Woody. Stomata numerous on both sides. Internal glands absent. Clustered crystals found near the veins of the leaf and in the collenchyma, soft bast and pith of the axis. Clothing hairs tufted and equally numerous on both sides. External glands club-shaped and equally numerous on both the sides. Cortex characterised by cork and collenchyma. Wood uniformly broad. Vascular bundles occurring in the pith. Medullary rays 1-3 seriate. Pith formed of thick-walled cells.

Pavonia arabica *Steud.*—Woody. Stomata more numerous on the lower surface. Secretory cavities numerous in the mesophyll. Clustered crystals abundant in the leaf and axis. Clothing hairs tufted and more numerous on the lower surface. Tufted hairs along with simple thick-walled unicellular hairs found on the axis. Assimilatory tissue formed of chlorenchyma. Bast fibres occurring in the soft bast. Wood reduced on the lower side of the inclined axis. Medullary rays uniseriate. Pith formed of thin-walled cells.

Hibiscus micranthus *Lf.*—Pl. VIII, figs. 57, 58. Woody. Stomata more numerous on the lower surface. Internal glands absent in the leaf and axis. Clustered crystals found near the veins in the leaf, and in the collenchyma and pith of the axis. Clothing hairs tufted. External glands club-shaped and few on the leaf and axis. Assimilatory tissue formed of palisade cells. Cortex characterised by collenchyma. Sclerenchymatous pericycle and wood reduced on the lower side of the inclined axis. Medullary rays 1-3 seriate. Pith formed of thin-walled cells.

Gossypium herbaceum *L.*—Figs. 59, 60. Woody. Stomata more numerous on the lower surface. Internal glands in the leaf and axis in the form secretory cells and secretory cavities. Some of the pith cells holding tanniniferous contents. Clothing hairs tufted. Glandular hairs spherical and more numerous on the upper surface of the leaf and numerous on the axis. Cork subepidermal. Sclerenchymatous pericycle and wood reduced on the lower side of the inclined axis. Medullary rays 1-3 seriate. Pith formed of thin-walled cells.

Structure of the Leaf :—Epidermal cells are tabular with outer-walls thickened and papillose. Lateral walls are straight. The surface of the leaf in *Abutilon fruticosum* is characterised by ridges and furrows. There are cells of considerable dimensions with water-

storage function intercalated amongst the ordinary epidermal cells in *Hibiscus micranthus* (fig. 57A). They are present on both the sides and have their inner walls convexly arched inwards so as to come into close contact with the assimilatory tissue.

The stomata are more numerous on the lower surface. The front cavity is placed in a depression formed by the outer thickened and papillose walls. The guard-cells are in the plane of the surrounding cells as in *Abutilon fruticosum* and *Sida grewioides* (fig. 53), or they are elevated as in other species. The elevated position of the guard-cells can be accounted for by the occurrence of a dense covering of tufted hairs. The mesophyll is composed of palisade tissue on the adaxial side and of arm-palisade tissue on the abaxial side. The palisade tissue in *Sida grewioides* is formed of compact cylindrical groups. The mesophyll is characterised by the abundance of internal glands in *Sida grewioides*, *Pavonia arabica* and *Gossypium herbaceum*.

The internal secretory organs in *Gossypium herbaceum* are represented partly by some of the palisade cells and a layer of polygonal cells above the arm-palisade tissue with tanniniferous contents and partly by mucilaginous secretory cavities with a lining layer of cells, and situated in the middle of the mesophyll and in the arm-palisade tissue. In *Pavonia arabica*, there are mucilaginous secretory cavities situated in the middle of the mesophyll below the vascular bundles of the veins. In *Sida grewioides* (fig. 53), there are groups of loosely arranged palisade-like cells, faintly green in colour and placed between groups of palisade cells ; there are also rounded or elliptical structures amongst the arm-palisade cells, also faintly green in colour. These structures in the mesophyll are either schizogenously formed internal secretory cavities or water-storage cells.

Oxalate lime occurs in the form of clustered crystals near the veins. In the axis clustered crystals occur in the cortex and pith of all species except *Pavonia arabica*. In *Sida grewioides* and *Pavonia arabica* numerous small-clustered crystals occur in the soft bast.

The veins are embedded except some of the larger veins in *Gossypium herbaceum* which are vertically transcurrent above and below partly by means of sclerenchyma and mostly by collenchyma. The veins are provided with bundle-sheaths of green thin-walled cells.

The hairy covering consists of densely placed tufted hairs. The rays are unicellular and are sunk directly in the epidermis, so that the hairs seem to be formed by a group of epidermal cells, fig. 55. The rays on the lower portion of the mid-rib are borne on a short multicellular stalk. The hairy covering is denser on the lower surface of the leaf.

Glandular hairs in *Abutilon fruticosum*, *Pavonia arabica* and *Hibiscus micranthus* (fig. 57) are club-shaped and are composed of a basal stalk-cell and of a head divided by horizontal and vertical walls. *Sida grewioides* (fig. 54) possesses pitcher-shaped uniseriate glandular hairs. External glands in *Gossypium herbaceum* (fig. 59) are spherical and are composed of a basal stalk-cell and of a head irregularly divided. External glands are numerous on both the surfaces of the leaf and are placed in depressions of the epidermis in all members except *Abutilon fruticosum*. They are more numerous on the lower surface in *Sida grewioides* and on the upper surface in *Gossypium herbaceum*.

Structure of the Axis :—The epidermis consists of small tabular cells with outer walls thickened and papillose. The lateral walls are straight. The hairy covering is composed of tufted hairs as described already. Besides the tufted hairs there are thick-walled unicellular hairs, resembling the rays of the tufted hairs, in *Pavonia arabica*. External glands occur on young branches and have the same characters as of those on the leaf.

The primary cortex is characterised by subepidermal cork in *Sida grewioides*, *Abutilon fruticosum* (fig. 56) and *Gossypium herbaceum* (fig. 60). Collenchyma occurs in the cortex in all members ; it may form long strands as in *Pavonia arabica* or a continuous ring as in other species. Assimilatory tissue consists of palisade cells in *Hibiscus micranthus* (fig. 54); in other species it is formed of chlorenchyma.

The pericycle is composed of closely placed rhomboidal groups of stone-cells ; it is reduced on the lower side of the inclined branches of *Hibiscus micranthus*. There are numerous small groups of bast fibres in the soft bast of *Sida grewioides* and *Pavonia arabica*.

The wood forms a composite hollow cylinder in all members. The vessels are small and arranged in closely placed rows. The interfascicular wood prosenchyma is not very extensive. The medullary rays are uniseriate in *Sida grewioides* and *Pavonia arabica ;* in others they are 1-3 seriate. In *Abutilon fruticosum* there occur vascular bundles in the pith close to the xylem cylinder. On a small portion of the axis in *Pavonia arabica*, *Hibiscus micranthus* and *Gossypium herbaceum* the wood is reduced ; in this portion of the axis the wood is much narrowed and vessels are few and small. This may be accounted for by the inclined nature of the axis, the wood being reduced on the lower side.

The pith consists of thick-walled cells in *Abutilon fruticosum ;* it is composed of thin-walled cells in others.

Internal glands occur in the cortex in the form of secretory

cavities with a lining layer of cells and with pinkish contents in *Gossypium herbaceum*. Oxalate of lime is found in the form clustered crystals in the soft bast in *Sida grewioides* and *Gossypium herbaceum* (fig. 60) in the cork, collenchyma, soft bast and pith of *Abutilon fruticosum* (fig. 56) and in the collenchyma of *Hibiscus micranthus* (fig. 58). Oxalate of lime does not occur in any form in *Pavonia arabica*.

Anamolous structures are represented by vascular bundles in the pith of *Abutilon fruticosum* as already mentioned.

General Review:—Epidermal cells are tabular with outer walls not much thickened. Large water-storing cells are intercalated amongst the ordinary epidermal cells in *Hibiscus micranthus* (fig. 57). Guard-cells are usually a little elevated. The front cavity is depressed. A dense covering of tufted hairs occurs on the leaves and young branches. External glands are either club-shaped (fig. 57), pitcher-shaped (fig. 54) or spherical (fig. 59); they are usually placed in epidermal depression.

The mesophyll is composed of palisade tissue on the adaxial side and of arm-palisade tissue on the abaxial side. Internal secretory organs occur in the leaf and axis in the form of secretory cells or secretory cavities. The veins are embedded except the larger ones in *Abutilon fruticosum;* they are provided with bundle-sheaths. Oxalate of lime is found in the form of clustered crystals in the leaf and axis. The assimilatory tissue in the axis is either composed of palisade tissue or of chlorenchyma. The cortex is usually strengthened by collenchyma. The cork is subepidermal. The pericycle is formed of rhomboidal groups of stone-cells. Numerous small groups of bast fibres are found in the soft bast of *Sida grewioides* and *Pavonia arabica*. The wood forms a composite hollow cylinder. The vessels are small and few. Interfascicular wood prosenchyma is not extensive. Medullary rays are 1-3 seriate. Vascular bundles occur in the pith of *Abutilon fruticosum*. The pith is formed of thin-walled cells.

STERCULIACEAE.

Melhania Denhamii *Br.* Figs. 61, 62. Lower surface of leaf deeply furrowed. Mesophyll formed of short palisade cells on the adaxial side and of arm-palisade ones on the abaxial side. Upper epidermal cells with tanniniferous contents. Numerous mucilage canals in the pith. Solitary crystals in the leaf and axis. Clothing hairs tufted. Glandular hairs club-shaped. Pericycle formed of an outer loose ring of stone-cells and of an inner loose ring of bast fibres. Vessels large. Medullary rays 1-3 seriate and broadening outwards in the form of wedges between the groups of soft bast.

Melhania magnifolia, Blatt. and Hall.

Lower surface of the leaf with furrows not deep. Mesophyll formed of palisade tissue on the adaxial side and of an arm-palisade tissue on the abaxial side. Numerous cells with tanniniferous contents near the veins. Solitary crystals occurring below the upper epidermis and near the veins of the leaf. Clothing hairs tufted. Glandular hairs club-shaped. Pericycle formed of a single loose ring of stone-cells. Vessels small and few. Medullary rays uniseriate. Mucilage canals in the pith few.

Structure of the Leaf:—Epidermal cells are tabular, with outer walls a little thickened and convexly arched outwards. Lateral walls are straight. The lower surface is characterised by furrows which are much deeper in *M. Denhamii*. Stomata are more numerous on the lower surface and occur in the furrows; they are surrounded by ordinary epidermal cells. Guard-cells are elevated and the front cavity is on a level with the surface. The mesophyll in *M. Denhamii* is composed of a homogeneous palisade tissue; in *M. magnifolia* there is a palisade tissue on the adaxial side and arm-palisade tissue on the abaxial side.

Internal glands are represented in the axis by cells with mucilaginous membranes in the cortical parenchyma and by numerous mucilage canals of schizogenous origin in the pith. In the leaf of *M. Denhamii* upper epidermal cells and numerous polygonal cells near the veins hold tanniniferous contents. Oxalate of lime occur in *M. Denhamii* in the form of solitary crystals near the veins of the leaf and in the cortical parenchyma and pith of the axis. In *M. magnifolia* bundles of solitary crystals occur near the veins and in a layer of tabular cells below the upper epidermis.

The veins are enclosed in green bundle-sheaths and are vertically transcurrent above by colourless parenchyma. The veins of the mid-rib are vertically transcurrent above by clourless thick-walled parenchyma and below by collenchyma.

Hairy covering on the leaf and axis consists of densely placed tufted hairs which are more numerous on the lower surface. The rays are unicellular and thick-walled and are sunk directly in the epidermis, so that the hairs seem to be formed by a group of epidermal cells (fig. 61). The rays on the lower surface of the mid-rib and on the axis are placed on a short multicellular stalk (fig. 62). The glandular hairs on the leaf and axis are club-shaped and are composed of a stalk-cell and a head divided by horizontal and vertical walls (fig. 62). The external glands are more on the upper surface and protect the palisade tissue against the strong light and glare by means of their secretions.

Structure of the Axis :—The epidermal cells are small and polygonal, with outer walls greatly thickened and convexly arched outwards. The cortex is characterised by subepidermal cork and by collenchyma. The assimilatory tissue is formed of chlorenchyma.

The pericycle in *M. Denhamii* is formed of an outer ring of groups of stone-cells and of an inner ring of radially elongated groups of bast fibres. The groups of stone-cells and of bast fibres are separated by colourless parenchyma. In *M. magnifolia* the pericycle is formed of a loose ring of groups of stone-cells.

The wood is composite and is much narrowed at two opposite points which probably represent the plane at right angles to that which is affected by the prevailing wind. The vessels in the broader portion are larger and less numerous. The wood in *M. magnifolia* is composite and is of uniform breadth. Interfascicular wood prosenchyma is extensive and is composed of cells with thick-walls and small lumina. Medullary rays in *M. Denhamii* are 1-3 seriate, broadening outwards in the form of wedges between the groups of soft bast and are in contact with parenchymatous cells separating the groups of stone-cells and of bast fibres. Medullary rays in *M. magnifolia* are uniseriate.

The pith is distinguished by the occurrence of mucilage canals and is composed of thin-walled cells.

TILIACEAE.

Grewia populifolia *Vahl.*—Front cavity placed in depressions formed by the thickened outer epidermal walls. Solitary crystals few and occurring near the veins and in the cortex. Veins vertically transcurrent above and below by sclerenchyma. Clothing hairs tufted. Glandular hairs club-shaped with the head divided by horizontal and vertical walls. Pericycle forming a composite ring of stone-cells. Medullary rays uniseriate.

Grewia villosa *Willd.*—Front cavity on a level with the surface. Solitary crystals numerous and occurring near the veins, in the cortex and pith. A few conglomerate crystals present near the veins. Veins vertically transcurrent above by sclerenchyma and below by bundle-sheath cells. Clothing hairs tufted. Glandular hairs club-shaped with the head divided by horizontal and vertical walls. Cork subepidermal with one or two layers of thickened and lignified cork-cells at its lower end. Pericycle formed of a composite ring of stone-cells. Medullary rays 1-2 seriate.

Grewia abutilifolia *Vent.*—Figs. 63, 64. Front cavity on a level with the surface. Solitary crystals few and occurring near

the veins and in the cortex. Veins vertically transcurrent above and below by sclerenchyma with water-storage tracheid-like structures at their terminations. Clothing hairs tufted and unicellular. Glandular hairs club-shaped with the head divided by horizontal and vertical walls. Pericycle of stone-cells and not composite. Medullary rays 1-3 seriate.

Corchorus trilocularis *L.*—Fig. 65. Clustered crystals near the veins and few. Glandular hairs club-shaped with the head divided by horizontal and vertical walls. Clothing hairs unicellular. Epidermis of the axis with outer walls considerably thickened and cuticularised. Lateral walls thickened. Wood narrowed on the lower portion of the inclined axis. Medullary rays uniseriate.

Corchorus antichorus *Raeus.*—Clustered crystals near the veins and few. Clothing hairs unicellular. Glandular hairs club-shaped with the head divided by horizontal and vertical walls. Epidermis of the axis with the outer walls greatly thickened and cuticularised. Lateral and inner walls also a little thickened. Medullary rays 1-2 seriate.

Corchorus tridens *L.*—Figs. 66, 67. Clustered crystals near the veins and numerous. Clothing hairs unicellular. Glandular hairs club-shaped and with the head divided by horizontal walls. Epidermis of the axis with outer walls greatly thickened and with lateral and inner walls also a little thickened. Medullary rays 1-2 seriate.

Structure of the Leaf:—The epidermis of the upper side consists of almost cubical cells and of the lower side of horizontally tabular cells. The outer walls are a little thickened; the inner and lateral walls are thin. The lateral walls are straight. Epidermal cells surrounding the stomata are usually much smaller and are of the nature of subsidiary cells.

The stomata are more numerous on the lower surface, while in species of *Grewia* they occur only on the lower surface. The guard-cells are elevated and the front cavity is on a level with the surface. In species of *Corchorus* epidermal cells on either side of the guard-cells are elevated and are much smaller than the ordinary epidermal cells; they seem to be of the nature of subsidiary-cells. The stomata on the axis are like those on the leaf.

The mesophyll is composed of palisade tissue on the upper side and of arm-palisade tissue on the lower.

Oxalate of lime occurs in the form of numerous clustered crystals near the veins in species of *Corchorus* (fig. 66). In species of *Grewia* solitary crystals are found near the veins (fig. 63), and in the cortex and

pith. Solitary crystals are sometimes found in groups of 3-4 in the cells ; they are sometimes also aggregated in the form of conglomerate crystals in the axis of species of *Grewia*.

The veins are embedded and are not provided with bundle-sheaths in species of *Corchorus*. The veins are vertically transcurrent above and below by sclerenchyma in *Grewia populifolia* and *Grewia abutilifolia* and above by sclerenchyma and below by sheath cells in *Grewia villosa*. The veins in species of *Grewia* are provided with bundle-sheaths. In *Grewia abutilifolia* there are structures of the nature of water-storing tracheids at the terminations of the veins.

Hairy covering on the leaf and axis consists of clothing and glandular hairs. The clothing hairs in species of *Corchorus* are unicellular, thick-walled and not dense (fig. 66). In *Grewia* they are tufted (figs. 63, 64), the constituent rays being unicellular and thick-walled. Besides the tufted hairs, there are unicellular thick-walled hairs, resembling the rays of the tufted hairs, on the axis of *Grewia abutilifolia* (fig. 63). The glandular hairs are club-shaped and are composed of a stalk-cell and of a head divided only by horizontal walls (figs. 65, 63), or by both horizontal and vertical walls (fig. 64).

Structure of the Axis :—The epidermis in species of *Corchorus* consists of horizontally tabular cells with outer walls thickened and arched convexly outwards, the thickening of the outer walls being quite considerable in *Corchorus trilocularis* and *Corchorus tridens*. The lateral and inner walls are also thickened. The epidermal cells in species of *Grewia* are horizontally tabular and are uniformly thickened on all sides. The lateral walls are straight in members of both the genera.

The cortex is characterised by subepidermal cork in species of *Grewia*, the innermost layers of which in *G. villosa* are composed of thickened and lignified cork-cells. Cork does not occur in species of *Corchorus*. Three tissues may be distinguished in the cortex : in species of *Corchorus* outermost parenchyma, middle collenchyma and innermost parenchyma ; in species of *Grewia* outermost cork, middle collenchyma and innermost parenchyma.

Internal secretory organs are represented in the axis of members of both the genera by mucilage cavities in the cortical parenchyma (figs. 67, 64) and in the pith (fig. 64).

The pericycle is composed of closely placed groups of stone-cells with very small lumina (figs. 64, 67). The wood forms a composite hollow cylinder. The vessels are arranged in rows. The interfascicular wood prosenchyma is extensive and is composed of cells with wide lumina. The medullary rays are numerous ; they are uniseriate in *C. trilocularis*, *G. populifolia* and *G. villosa*, 1-2 seriate in *C.*

anti-chorus and *C. tridens* and 1-3 seriate in *G. abutilifolia*. Wood parenchyma is poorly developed.

The wood in *C. trilocularis* is narrowed on one side, the narrowed portion being characterised by a larger number of vessels and the broader portion by more extensive wood prosenchyma. These modifications in the structure of the wood may be the result of the inclined nature of the axis, the narrowed portion being situated on the lower side of the inclined axis. The abundance of wood prosenchyma on the upper side prevents the axis from bending.

The pith is composed of thin-walled cells in species of *Corchorus* and of thick-walled cells in species of *Grewia*.

General Review :—There are a number of characters which can be used for the diagnosis of the two genera.

Corchorus :—Stomata with smaller epidermal cells on either side of the guard-cells. Oxalate of lime in the form of clustered crystals near the veins. Veins embedded and not provided with bundle-sheaths. Clothing hairs unicellular. Outer walls of epidermal cells of the axis greatly thickened and cuticularised. Cortex composed of three zones—outermost parenchyma, middle collenchyma and innermost parenchyma. Pith composed of thin-walled cells.

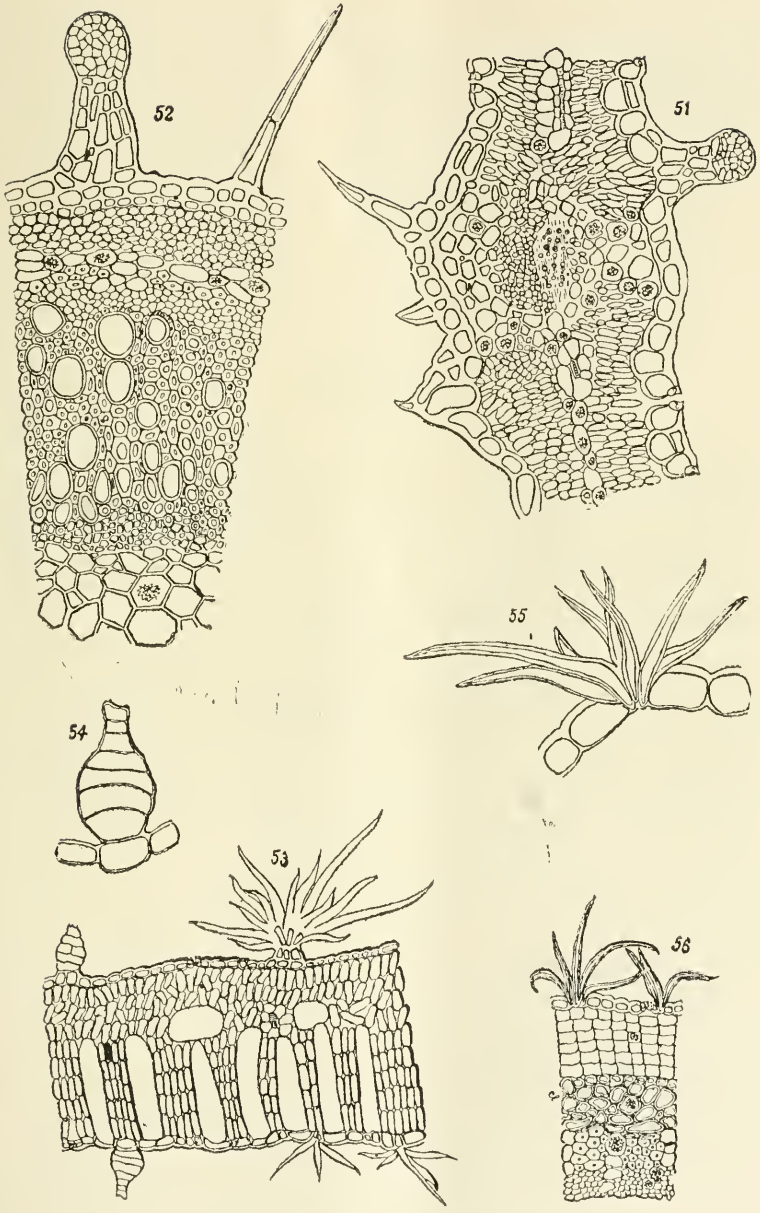
Grewia :—Stomata with ordinary epidermal cells on either side of the guard-cells. Oxalate of lime in the form of solitary crystals. Veins vertically transcurrent and provided with green bundle-sheaths. Clothing hairs usually tufted. Epidermal cells of the axis uniformly thickened on all sides. Cortex composed of three zones—outermost cork, middle collenchyma, innermost parenchyma. Pith formed of thick-walled cells.

(*To be continued.*)

Plate VII

51-52. *Bergia odorata.*
51 T.S. of the leaf.
Oc. 3 ; Ob. C.
52 T.S. of the axis.
Oc. 3 ; Ob. C.
53-54. *Sida grewioides.*
53 T.S. of the leaf.
Oc. 6 Com. ; Ob. 8 mm. Ap.
54 Glandular hair on the leaf.
Oc. 6 Com. ; Ob. 3 mm. Ap.
55-56. *Abutilon fruticosum.*
55 Hair on the leaf.
Oc. 6 Com. ; Ob. 3 mm. Ap.
56 T.S. of the axis.
Oc. 6 Com. ; Ob. 8 mm. Ap.

N.B.—To get the original dimensions multiply by 1·7.

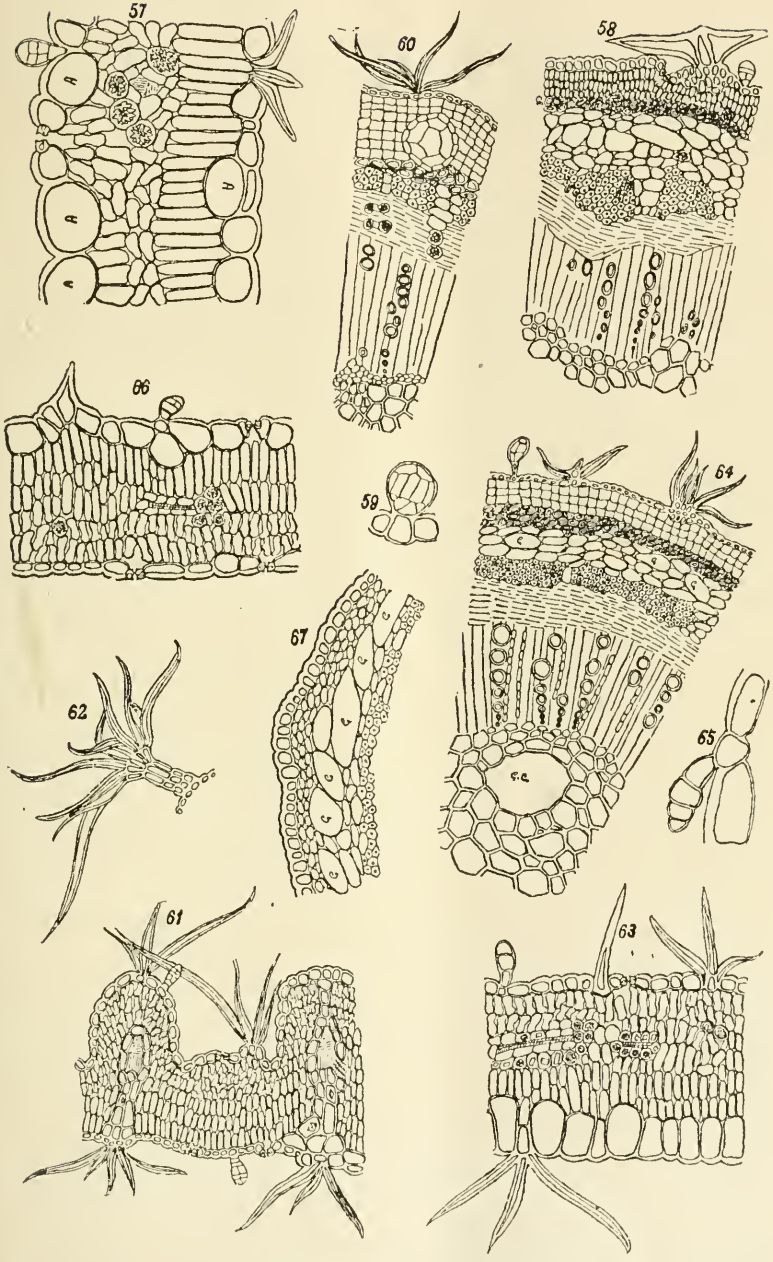


T. S. Sabnis del. PLATE VII.

Plate VIII

57-58. *Hibiscus micranthus.*
57 T.S. of the leaf.
Oc. 4 Com.; Ob. 3 mm. Ap.
58 T.S. of the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.
59-60. *Gossypium herbaceum.*
59 Glandular hair on the leaf.
Oc. 6 Com.; Ob. 3 mm. Ap.
60 T.S. of the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.
61-62. *Melhania Denhamii.*
61 T.S. of the leaf.
Oc. 6 Com.; Ob. 8 mm. Ap.
62 Hair on the axis.
Oc. 6 Com.; Ob. 8 mm. Ap.
63-64. *Grewia abutilifolia.*
63 T.S. of the leaf.
Ob. 6 Com.; Ob. 8 mm. Ap.
64 T.S. of the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.
65. *Corchorus trilocularis.*
Glandular hair.
Oc. 6 Com.; Ob. 3 mm. Ap.
66-67. *Corchorus tridens.*
66 T.S. of the leaf.
Oc. 6 Com.; Ob. 8 mm. Ap.
67 T.S. of the axis showing the epidermis and cortex.
Oc. 6 Com.; Ob. 8 mm. Ap.

N.B.—To get the original dimensions multiply by 1·7.



T. S. Sabnis del. PLATE VIII.

ABNORMAL NUMBER OF NEEDLES IN THE SPURS OF PINUS LONGIFOLIA

BY

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Pinus Longifolia is a common connifer of the outer hills of the Punjab Himalayas and is often cultivated in the plains. The number of leaves in the dwarf shoots in this species is described in the Indian Floras[1] as three. So constant is this number in the *adult* plant that the writer has not come across a single example of a different number during many years for which the plant has been a subject of study in the Botany classes at the Lahore Government College and in spite of a careful examination of several trees recently. It came as a surprise therefore when, last year, while examining a seedling he came across an abnormality in this respect quite by chance. On examining the seedling further and later on examining more seedlings many such instances were found. On looking up the literature[2] of the subject it was found that the abnormal number of needles in the spurs of many species both in the seedling and the adult plant is by no means rare though no mention of *Pinus longifolia* has been met with anywhere. Among a pretty large number of species mentioned by Thomson (Botanical Gazette, May, 1914) in this connection, *Pinus excelsa* is the only Indian species. Again although a number of observations are recorded in the papers mentioned yet the writer has not come across any quantitive study of this subject. This paper records a short study of this kind.

In order to find out the relative frequency of plants with abnormal spurs as regards the number of needles and the relative number of different kinds of such spurs on the same plant one hundred and one seedlings were taken from the nursery of the Lawrence Gardens, Lahore, through the courtesy of the Superintendent, and carefully

[1] Hooker: *Flora of British India;* Brandis: *Indian Trees,* also his *Forest Flora ;* Parker : *Forest Flora of the Punjab,* etc. Among other standard books on this subject may be mentioned Elwes and Henry : *The Trees of Great Britain and Ireland.*

[2] Thomson, R. B.: The Spur Shoots of the Pines. *Bot. Gazette, May, 1914.* Dufrenoy, J. : Pine Needles, Their significance and History. *Bot. Gaz., November, 1918.* Reference to other literature bearing on this point is given in these papers.

examined as regards their general condition, height, branching, dwarf-shoots, etc., by L. Ram Lal Sethi, M.Sc., Demonstrator of Botany at the Government College. As he had to leave for Europe immediately after the completion of these observations the writer looked up the literature and prepared the analysis. The seedlings were about four years of age and varied in height from 11 inches to 22 inches. All the plants had been kept under the same conditions along with many others.

As is well known young seedlings bear only scattered green leaves and scale-leaves and dwarf-shoots are developed only gradually. Of the 101 seedlings one did not possess any dwarf-shoots at all and was unbranched. Otherwise the plant was erect and healthy so far as could be seen. No further notice will be taken of this plant. All the remaining one hundred possessed dwarf-shoots and a great many possessed long shoots in addition. No plants were found with abnormal shoots only, but normal and abnormal shoots were mixed in more than one half, 57 per cent. to be exact. The abnormal number of needles was 2, 4 or 5. No spur was found with 1 or more than 5 needles. The analysis is given below :—

Plants examined : 100. All with dwarf-shoots.			
Plants with 3-leaved shoots only		43	
Plants with abnormal shoots in addition to 3-leaved shoots		57	
Plants with 2-leaved abnormal shoots only		2	
Do.	4-leaved abnormal shoots only	40	
Do.	5-leaved abnormal shoots only	2	
Do.	2-and 4-leaved abnormal shoots	6	57
Do.	2-and 5-leaved abnormal shoots	0	
Do.	4-and 5-leaved abnormal shoots	3	
Do.	2—4-and 5-leaved abnormal shoots	4	

It will be seen from the above that plants with 4-leaved abnormal shoots only are by far the most common. If we add to these the plants that bear 4-leaved shoots in addition to other abnormal shoots the number becomes still larger, *i.e.*, 53. The relative number of shoots is given below :—

Plants examined : 100 as above, of which 57 possessed abnormal shoots.	
2-leaved shoots in all the plants	17
4-leaved shoots in all the plants	145
5-leaved shoots in all the plants	11

It is clear that the 4-leaved shoots are by far the most common of all the abnormal shoots. It may be mentioned here that the number of 3-leaved shoots on these plants was very variable. It ranged from a few to about 300 on each plant.

The co-relation of the presence of the long shoots to the number of abnormal dwarf shoots is shown below :—

Plants with long shoots (branched) ...	...	90
Plants without long shoots (unbranched)...	...	10
Plants with normal shoots only ...	... 5	10
Plants with abnormal shoots also ...	... 5	

It will be seen from this that 50 % unbranched plants show the presence of abnormal shoots in addition to the normal shoots, while 52 out of 90, *i.e.*, nearly 58 %, of branched plants possess the same peculiarity. This small difference has probably no significance. A very interesting point, however, is that that all the abnormal shoots on these 5 plants were 4-leaved. The details are as follows :—

Two plants possessed only one such shoot each ; one possessed 5 such shoots ; one possessed 8 such shoots, and one possessed 13 such shoots. This last plant was growing in a larger pot than the others.

This relation between the absence of long shoots and the presence of 4-leaved abnormal dwarf shoots only (of course in addition to normal shoots) can hardly be accidental. Of course some branched plants also had 4-leaved shoots, either alone or along with other abnormal shoots, but no unbranched plants were found with any but 4-leaved abnormal shoots. The large size of the pot in one case may explain the large number of the 4-leaved shoots in that plant, but hardly the fact that all shoots were 4-leaved and not even one 5-leaved. Another fact which was noticed in this connection was that plants with few and small branches showed a greater tendency on the whole to form abnormal shoots than plants with long and many shoots but no exact numbers were obtained.

Below is given an analysis of the plants which possessed *five or more* abnormal shoots. The total number of such plants was 12. Nine plants had purely 4-leaved shoots as follows :—

4 with 5 such shoots.

1 with 7 such shoots.

2 with 8 such shoots.

1 with 10 such shoots.

1 with 13 such shoots.

A combination of 2-and 4-leaved shoots with more than five shoots occurred in one plant :—2-leaved shoots, 2 ; 4-leaved shoots, 5.

A combination of 4-and 5-leaved shoots with more than five shoots occurred in one plant :—4-leaved shoots, 8 ; 5-leaved shoots, 3.

A combination of 2-, 4-and 5-leaved shoots with more than five shoots occurred in one plant :—2-leaved shoots, 1 ; 4-leaved shoots, 7 ; 5-leaved shoots, 1.

As regards the position of the abnormal shoots on the plant no special relationship could be found. They occurred scattered on the plant. This point is also referred to take on in the paper.

The length of the needles of the abnormal shoots was also measured but no special relationship with the length of the needles of the normal shoots could be made out.

It will be seen from what has been described before that 4-leaved spurs are by far the most common of abnormal shoots in the seedlings of *Pinus longifolia* forming as they do 83·8 % of the whole lot of abnormal shoots. Tbe actual numbers observed in one hundred plants were 145 out of 173. The numbers of 2-leaved and 5-leaved shoots were 17 and 11 respectively. (The normal number of leaves in the dwarf shoot is three and according to the observations of the writer variations in the adult plants is extremely rare.) The seedlings show therefore that a very great majority of abnormal shoots possess a larger number of leaves than the normal shoots. This is contrary to the observations of Thomson who says (Bot. Gaz., May, 1914):—"It is more usual to find the spurs poorly developed when they first appear on the seedling This feature shows itself especially in species which have normally more than two leaves in the mature condition." Out of the 57 plants with abnormal shoots only two possessed 2-leaved abnormal shoots only, and ten more which possessed 2-leaved shoots in addition to other forms of abnormal shoots did not show that the 2-leaved shoots were in every case the first formed abnormal shoots. In one the only 2-leaved shoots present was near the top above some other abnormal shoots, but in the other nine the shoots were near the base.

The writer is however in perfect agreement with the conclusion arrived at by Thomson when he says:" The lack of definiteness in the number of leaves in a fascicle, and the occurrence of supernumerary needles in the recognised primitive region and after wounding, are evidence of the branch character of the spur of the pines." He points out also that the normal proliferation of the spur in the seedling and young plant into an ordinary branch with both primordial and fascicled leaves, and the traumatic revival of this condition in the mature tree place this conclusion beyond reasonable doubt, strengthened as it is by the normal occurrence of the spirally arranged leaves in the seedling and other facts.

According to this view it would also appear that species of pine possessing a smaller number of leaves in their spurs are more specialised than the others and the tendency has been towards forming spurs with fewer and fewer leaves. This conclusion is also supported by the facts reported by Boodle (New Phytologist, 1915):—"In

Pinus monophylla the spur shoots as a rule bear each a single needle, but two are occasionally present. Masters found by studying early stages that two leaf-rudiments are always produced, but that one of them generally becomes arrested at an early stage."

A paper on the comparative anatomy of the needles of the seedlings and mature plants is in preparation.

The main conclusions of the paper may be stated as folllows :—

1. Spurs with more or less than three needles in the adult plants of *Pinus longifolia* as seen in Lahore are extremely rare.

2. Spurs with more or less than three leaves are very common in seedlings. Fifty-seven per cent. seedlings possesses such abnormal spurs.

3. Spurs with 4-leaves are the commonest of all, being 83·8 % of all abnormal shoots.

4. The conclusion is drawn from these facts that a 3-leaved spur has been derived from a spur with more leaves, that the spur is equivalent to an ordinary shoot and that pines with a small number of needles in their spurs are more highly specialised than species with a larger number of needles.

ON THE USE OF THE TERM "VARIETY" IN SYSTEMATICS.

BY

L. J. SEDGWICK, F.L.S.

The remarks which follow are based on practical experience as a field worker only, and the writer hopes that readers of the Journal will accept this limitation when considering them. The main questions brought up for discussion are: (1) whether the term *variety* as used in our Floras is applied to one natural phenomenon only, or at the worst to several phenomena which are perfectly homologous, and if not, then (2) whether there is any way of separating out the various phenomena hitherto confused under the one term, and assigning to each a separate term; since it is clearly unscientific to use one and the same term for phenomena which are heterologous.

It is usually assumed that in all taxonomic work the personal equation enters largely, and cannot be eliminated. It is open to question whether the latter part of this assumption is correct so far as species and units lower than the species are concerned. So far as concerns genera, families and all units above the species, since these taxonomic divisions are based on assumed descent, and since for the descent of plants our only material is the very fragmentary palæontological record, it is clear that our results must largely depend upon guess work. And it is for that reason that the tendency of even our deepest systematic thinkers to allow their generic divisions to be (sometimes at any rate) influenced by considerations of convenience is a comparatively venial sin. In the case of species however and all intra-specific units—excluding of course extinct species—there is no possibility of pleading lack of evidence. If into our discrimination of species the personal equation enters the fault is ours. We are hampered by weakness of power of perception, by shortage of workers, by lack of time, and by idiosyncrasies that could be eliminated. But the truths are there if we could only unravel them. In the case of most "critical" species the number of available individuals is legion. Mendelian and other experiments could be carried out. Even if the species or group of species is in an active state of evolution at the moment its different forms and developmental tendencies could be enumerated and charted. For instance, to take an imaginary case of an Indian genus believed to be in an active condition of

evolution, if the State cared to engage 100 trained observers to collect, observe and measure, and 10 trained systematists to examine and collate results for five years, facts would emerge at the end which would establish, at any rate for the time being, the limits of species and lower units and their developmental tendencies. The writer is not for a moment advocating such a course of action as a practical way of spending the State finances! The illustration is merely given by way of showing that so long as the evidence is completely available no problem is absolutely beyond solution. In short, where we find in the floras so-called " critical species " their critical character is due to human infirmity, and is not absolute.

Generally speaking all Indian workers seem to find that where the Flora of British India gives many *varieties* a mixture of species may be suspected, which patient collecting and collection of material will (and as a fact often does) clear up. Conversely it must be admitted that some species in the Floras can be broken down by patient collection of transitional series. Those two facts would go a long way towards establishing the truth of the proposition enunciated in the preceding paragraph. But unfortunately, partly owing to post-Linnæan and especially modern Mendelian researches into the origin of species, and partly owing to the extremely minute examination to which certain particular genera have been subjected in the West, and the recognition thereby of numerous intra-specific forms, there has been of late years a strong tendency to cast scorn upon Systematics, and even to take the final step of asserting that the individual is the only ultimate unit. Fortunately, however, both the economist who obtains products from plants and the field-worker who observes and collects them, know that the individual is only the unit in the same sense that no two members of one nation or even of one household are exactly alike, and that just as human beings can be and must be grouped into larger units on various scientific and social basses, so among plants there are units containing millions—often countless millions—of individuals, whose common characters can and must be described, and to which the application of a " barbarous binomial " is both convenient and necessary.

The unit commonly accepted and used for more that a century and a half is the Linnæan species. And it is this particular unit upon which some students of genetics to-day seem to cast such scorn, regarding it as an erroneous conception and no true phenomenon. Now this view is one which the writer believes to be wrong. The practical field-worker knows that in a region with which he is familiar he can at once assign to their Linnæan species all but an

infinitesimal fraction of the plants that he sees around him. Of that fraction many are simply freaks or sports; and as there is a tendency for such freaks to be collected and to find their way into herbaria it follows that herbaria may often give an exaggerated impression of the range of variability of species generally. Into the genetic phenomenon of freaks this paper cannot enter.

Over and above freaks we have to recognize a number of other types of variability.

First there is the phenomenon of geographical change, which may be either gradual or sudden. As an example of the first, the colour of the spikelets of many *Cyperaceæ* and *Gramineæ* is paler in North India and gradually darkens as one goes south, until on the Nilgiris it is almost black. As an example of the second, *Ageratum conyzoides* Linn. is on the Nilgiris a delicate-stemmed plant with pure mauve flowers, while in the Dharwar District of the Bombay Presidency it is a coarse-stemmed and coarse-leaved plant with dirty white flowers. The causes of geographical change are very obscure. Complex climatic factors have to be reckoned with, as well as geological formations. There is also the phenomenon of isolation of "lines," which are discussed below.

Secondly there is a type of variability of a purely edaphic character within the same geographical region. Thus *Flueggea leucopyros* Willd. would seem to be merely an edaphic (xerophytic) form of *F. microcarpa* Bl.; *Leucas montana* Sr. would seem to be the xerophytic form of *L. mollissima* Wall. The various edaphic forms of many species not hitherto split off by the Floras are well known.

Thirdly there are distinct cases of variability in life-period. Thus *Fimbristylis diphylla* Vahl., a perennial, has an annual form var. *annua* (sp.) R. and S.: and similarly *Cyperus Iria* L. (see p. 693 of Journ. Bom. Nat. Hist. Soc. Vol. XXV No. 4). *Cyperus flavidus* Retz. would seem to be only an annual form of *C. Haspan* L.

Fourthly there would seem to be plants which exhibit a sort of seasonal dimorphism, not of course homologous with the same phenomenon in insects. Thus some species of *Smithia* have small flowers when they mature in the rains and large ones when they mature in the dry weather. *S. flava* Dalz. (var. in Cooke. F. Bom. Pres.), if not a valid species is apparently a seasonal form of *S. sensitiva* Ait.; while last winter the writer found at Yellapur in North Kanara a plant which corresponded exactly with *S. bigemina* Dalz. except that it was much larger in all its parts especially the flowers, and had matured in the winter instead of the rainy season.

Fifthly there is the much more difficult phenomenon of "lines". That these are due to the interplay of Mendelian characters is now

apparently established. As said above; geographical changes of an abrupt type are probably caused by isolation of lines. The result of isolating lines is well seen in the cultivated cereals. In natural conditions isolation is much less frequent; in fact it would not be too much to say that Nature abhors a pure line, just as she abhors the inter-specific cross. And it is these two facts alone which secure the stability and continuity of the Linnæan species. Nevertheless varieties due to isolation of lines without geographical isolation almost certainly do occur,—for instance *Scirdus supinus* var. *uniondis* Cke, and *Cyperus Iria* var. *paniciformis* Cke.

Sixthly there are the not infrequent cases of species and genera which are in an active state of evolution, producing a maze of forms among which clear specific lines of demarcation are not discernible. These forms may be the De Vriesian mutants. It would be beyond the scope of this paper to discuss this point; but it is necessary for the argument to say that whereas "lines" seem to be the product of isolation and combination of already existing, stable allelomorphs, the changing evolutionary forms now referred to would seem to be caused by instability of the allelomorphs themselves, which in such cases are disappearing and reappearing with changed properties.

Seventhly (although they stand on quite a different footing) it is necessary to refer to inter-specific hybrids, which though normally abhorred by Nature, do occur, and will ultimately be detected in India as they have been in Europe.

Now, omitting hybrids, our floras have for the most part in the past called all these varied forms of whatever origin by the one word variety. It is true that in cases of species with a very great range of variability the forms have sometimes not been given a varietal name, but simply listed under numbers or letters. But it would appear that this has been due more to convenience than to a clear discernment of the different phenomena.

Before considering the use of terms for units below the species it is desirable to consider whether we are justified in using the same term "species", undifferentiated, for the Linnæan group of individuals in which the allelomorphs are stable as well as for those in which they are unstable. The writer would suggest that the two phenomena be distinguished as "*species* (*constans*)", *and* "*species inconstans*", omitting in practice the word *constans*.

For units below the species the following scheme is suggested:—

A. For freaks or sports no special term, each one to be separately described.

B. (1) For geographical forms, where sharply distinguishable, the trinomial system now used by ornithologists.

(2) For edaphic forms the term *varietas* followed by the ordinary ecological term such as *ophytica halophytica*, etc.

(3) For life-period forms *varietas annua*, *biennia*, etc.

(4) For seasonal forms *varietas hyemalis*, *aestivalis*, etc.

(5) For "lines" *varietas Mendeliana* followed by the letters of the Greek alphabet.

(6) For forms of inconstant species *forma* is the ultimate unit, to be grouped about recognizable lines of evolution in various ways. For this case it is not possible to suggest hard and fast rules. The study of these inconstant species is a special one, for which the name micro-systematics might be used. A good many European and American genera have been studied in minute detail, and recently *Ammannia* and *Rotala* in India by Blatter and Hallberg in Journ. Bom. Nat. Hist Soc.

C. For hybrids the usual multiplication sign.

It will be argued that we do not know which variant forms are to be assigned to which class in the above scheme. And this is true. But temporary ignorance is no valid excuse for continuing to confuse under one term phenomena which are not homologous. Gradually the truth will emerge.

SHORT NOTES ON DISTRIBUTION, ETC.

I had an opportunity of running through some of Mr. P. F. Fyson's plants recently collected in the Nilgris and I find two of them rather interesting.

Juncus bufonius *Linn.* so far known to occur only in Northern India from the plains to 13,000 ft. in the Himalayas, is a new find at 7,000 ft. in a marsh 6 miles out of Ootacamund. This plant like a few other adds to the 'floristic affinity' which to a certain extent exists between the Nilgiris and the Himalayan region. Fruiting in September.

Pyrenacantha volubilis *Hook.* A dioecious climber which has thus far been recorded in the Madras Herbarium from Kambakkam (Chingleput), Madura and Tinnevelly hills and noted in Gamble's Madras Flora as collected only in the Pulney and Tinnevelly hills, also hails from Kallar at 1,500 ft. on the Nilgris. The piece collected is of a male plant. Flowers in October.

16-10 19. C. TADULINGAM.

Impatiens Tangachee *Bedd*—in Gamble's new Flora of the Madras Presidency is given as occurring on the Western Ghats, in river beds on the higher slopes of the Annamalais, above 4,000 ft. and in the 'Bolumpatti Hills of Coimbatore.' Fourteen years ago I was shown the plant growing in a stream at about 5,000 ft. on the Pulneys, by an enthusiastic amateur collector, who pointed out that as it was rare it would be well not to make its whereabouts known generally. Dr., now Sir Alfred, Bourne had also collected the species from the same stream, in 1899.

Heterocarpus *Wight*—was a genus differing from *Commelina* mainly in the fruit, of which one cell contains one seed only and remains indehiscent and attached to the pedicel, the other two cells each with two seeds falling away. Last year I collected on the higher downs of the Pulneys two plants, identical in every way except that one is hairy all over and the other glabrous, of a blue flowered *Commelina* which Mr. C. C. Calder, of the Royal Botanic Gardens, Calcutta, tells me are undoubtedly Wight's *Heterocarpus glaber* and *H. hirsutus:* but points out that according to Wight the flowers are yellow. I find on enquiry at the herbarium in Coimbatore that the species of *Heterocarpus*, *H. glaber*, collected in Palghat (Wight's locality) is certainly yellow or orange. A specimen of

what has been taken to be Wight's *H. hirsutus* has rather broader leaves than Wight's illustration, (Ic. Pl. In. Or. t. 2067) shows but is probably the same species, and the illustration might have been drawn from my plant. (Comp. the plate opposite). It would seem therefore that Wight's *H. hirsutus* and perhaps also *H. glaber*, has orange flowers on the lower slopes and blue flowers on the higher, and that they are two varieties a glabrous and a hairy of one species. A change from pink or purple to blue is common enough but orange and blue are not as a rule I believe, interchangeable, a blue colour being usually in the cell sap, but an orange in plastids. Possibly we have in these four plants two pairs of Mendelian allelomorphs segregating; hair and their absence, and orange and blue colours. Both forms were abundant where I found them, and growing side by side.

It would be interesting therefore to know whether there are any cases known of a species having blue flowers in one place and orange flowers in another.

The flowers of **Hydnocarpus alpinus** *Wtk* are typically dioecious. Recently I found near Coonoor a single male flower on a female tree, with pistillate flowers and fruits above and below on the same branch. Such an occurrence is probably not uncommon, though seldom recorded. Davy and Gibson described*, the occurrence of both sexes on the same plant of *Myrica Gale* a typically 'unisexual' dioecious species, and what, was more interesting, observed a change from maleness to femaleness between one year and the next on more than one plant.

Ever since the discovery of chromosome reduction we have been compelled to consider higher plants and ferns as never really sexual at all, sex appearing only in the last divisions of the cells which produce the pollen grains and ovule respectively. But where the flowers are unisexual the visible 'sex' may be dependent on external conditions, and is known to be affected sometimes by parasites. The object of this note is to call attention to this, for in India we have many plants with unisexual flowers *e.g.* spp. of sterculic, Terminalia, Piper, Myristica and observations of these, from year to year, by those in a position to make them, might lead to the discovery of the conditions which affect 'sex' (though if as seems likely sex is a Mendelian character, only in heterozygous individuals) or in the relative numbers of male and female flowers, with results perhaps of both scientific and economic importance.

P. F. FYSON.

* Davy, A. J., and Gibson, C. M. Note on the Distribution of Sexes in *Myrica Gale* *New Phyl.* XVI (1917), pp. 147—151.











D. R. Fyson del. COMMELINA *sp.*

CONTRIBUTIONS TOWARDS A FLORA OF BALUCHISTAN.

From materials supplied by Col. J. E. B. Hotson, I.A.R.O.

BY

E. Blatter, S.J., Prof. F. Hallberg and C. McCann.

St. Xavier's Coll., Bombay.

(*Continued from last issue*)

Geraniaceae—(*Cont.*)

Erodium sp. (*sine fructu*). Loc.: Garmkan, 1 mile NE of Panjgur, about 3,125 ft. (no. M 163). Fl. in March 1918.

Rutaceae.

Ruta *L.*

Ruta villosa *M. B. Taur. Cauc. 310.* Loc.: Pirandar, 205 miles SSW of Kalat, about 1,500 ft. (no. M 262). Fl. in Sept. 1917. *Vern. Name:* Gandarim (Bal. Br.).

Ruta stocksiana *Burkill Fl. Pl. Baluchistan (1909) 17.* Loc.: Rek Chah, 11 miles E. of Chambar (Kolwa), about 1,800 ft. (no. M 268). Fl. in April 1918. *Vern. Name:* Sadaf (Bal.), Gandarim (Br.).

Ruta tuberculata *Forsk. Fl. Aeg. Arab. 86.* Loc.: Khozdar, 27° 48′ N., 66° 37′ E., about 4,100 ft. (no. 341). Fl. in Sept. 1917. *Vern. Name:* Sadap (Bal. and ? Br.).

Meliaceae.

Melia *L.*

Melia azedarach *L. Sp. Pl. (1753) 384.* Loc.: Nal. 27° 41′ N. 66° 13′ E. 3,834 ft. (no 339, 339A).
Vern. Name: Bakkan (Br.), Bakan (Bal.)

Celastraceae.

Gymnosporia *W. & A.*

Gymnosporia spinosa *Fiori Bos. e Pint. legn. Eritrea (1909) 225* (G. montana *Benth*). Loc.: Rar Kaur, about 165 miles S. by W. of Kalat, 4,000 ft. (no. 120B). Fl. in Sept. 1917.
Vern. Name: Kotor (Br. Bal.).

Gymnosporia royleana *M. A. Laws. in Hook. f. Fl. Brit. Ind. I, 620.* Loc.: Hills S. of Chambar (Kolwa), 26° 9′ N. 64° 42′ E., about 1,900—2,300 ft. (no. M 76 B); Bagai Daf (Mantar), about 42 miles S. of Panjgur, about 3,100 ft. (no. M 76 A).
Vern. Name: Kotor (Bal.).

Rhamnaceae.

ZIZYPHUS *Juss.*

Zizyphus jujuba *Lam. Dict. III, 318.* Loc.: Near Kochau, 122 miles SSW of Kalat, about 4,100 ft. (no. 211 A) Turbat (Kech), about 600 ft. (no. M 1, M 1A) summit of Burida Pass, 140 miles SSW of Kalat, about 4,250 ft. (no. 211); Nigindap (Kharan), about 50 miles ENE of Panjguri, about 4,000 ft. (no. M 1B). Fl. in. Aug. 1917.—Fr. in Nov. 1917. *Vern. Names*: Ber, Kunar (Bal.), Pissi (Br.).

RHAMNUS *L.*

Rhamnus punctata *Boiss. Diagn. ser. I, II, 4.* Loc.: Rar Kaur. 165 miles S. by W. of Kalat, about 3,500 ft. (no. 152 A).
Vern. Name: Biruri (Br. Bal.).

Rhamnus persica *Boiss. Diagn. ser. I, II, 4.* Loc.: Ornach, 3,080 ft. (no. 318). *Vern. Name*: Jugar (Bal.).

Rhamnus spathulaefolia *F. & M. Ind. Petro. IV, 46.* Loc.: Near Shahdadzai, 72 miles S. of Kalat, 5,100 ft. (no. 151).
Vern. Name: Biruri (Br.).

Sapindaceae.

STOCKSIA *Benth.*

Stocksia brahuica *Benth. in Hook. Kew Journ. V, 304.* Loc.: Sitani, 59 miles S. of Kalat, 5,300 ft. (no. 120). Fl. in Aug. 1917, *Vern. Names*: Kotor (Br.), Zirok (Bal.).

DODONAEA *L.*

Dodonaea viscosa *L. Mant. 233.* Loc.: Hodal Pass (S. side), about 85 miles S. of Panjgur, at 2,400—2,900 ft. (no. M 164 A); Rar Kaur, 165 miles S. by W. of Kalat, about 3,500 ft. (no. 295); Kulbar valley, about 30 miles ENE of Mand, about 1,400 ft. (no. 104). Fl. and fr. in March and April 1918.
Vern. Names: Ghetichk (Bal.), Hamartrik (Br.).

Anacardiaceae.

MANGIFERA *L.*

Mangifera indica *L. Sp. Pl. (1753) 200.* Loc.: Turbat, 63° 4′ E. 25° 58′ N., about 600 ft. (no. M 53). Fl. Feb. 1918.
Vern. Name: Amb (Bal. etc.).
Note: The Turbat mangoes are regarded as very good in Makran.

PISTACIA *L.*

Pistacia Khinjuk *Stocks in Kew Journ. IV. 143.* Loc.: Summit of Burida Pass, between Bhani and Jebri, about 140 miles SSW of Kalat, about 4,250 ft. (no. 210, 210A); Kanoji, 47 miles N. of Las Bela, about 3,200 ft. (210B); Hodal Pass (N. side), about 80 miles S. of Panjgur, 2,800 ft. (M 221), very common on the southern side of the Pass (no. M 222); found from about 2,800 ft. down to about 2,500, where the Pass ends. Fr. in April 1918, in Aug. 1917.
Vern. Names: Kasur, Gwan (Bal. Br.).

Pistacia mutica *F. & M. in Hoh. Talysch Enum. 100.* Loc.: Under Harboi, 16 m ESE from Kalat (no. 46); Gwan berries were

brought in at Bhani, 131 miles SSW of Kalat, but no trees visible in the valley (4,000 ft). The trees are in the hills on either side (no. 202). Fr. in Aug. 1917. *Vern. Name* : Gwan.

RHUS *L.*

Rhus cotinus *L. Sp. Pl. 383.* Loc. : Hushtar Rahi Kaur, on the E. side of the Hushtar Rahi Pass, between Ornach (27° 0′ N, 66° 10′ E.) and Pelar (to West), about 3,700 ft. (no. 310, 301 A). Fr. in Sept. 1917. *Vern. Name* : Kaselo (Bal.).

Leguminosae.

ARGYROLOBIUM *Eckl. & Zeyh.*

Argyrolobium uniflorum *Boiss. Fl. Cr. II. 32.* Loc.: Kanoji, 47 miles N. of Las Bela, about 3,200 ft. (no. 391) ; Manguli, 26° 45. N. 65° 21′ E. about 2,600 ft. (no. M 269A). Fl. in April 1918, Oct. 1917. *Vern. Name* : Kahurkah (Bal.), at Manguli : Kahurbahar.

Argyrolobium Kotschyi *Boiss. Diagn. ser. I. VI, 32.* Loc. : Kalgali Kaur, N. of Zayakh Jangal, about 4,800 ft. (no. M 269C ; Kulbar valley, E. of Dagja, 62° 33′ E., 26° 15′ N, about 1,700 ft. (no. M 95A) ; Junction of Raghaiad and Gichk rivers, about 3,600 ft. (no. M 95D) ; Kulbar valley, about 25 miles ENE of Mand, about 1,300 ft. (no. M 106); Hills near Ispikan, about 20 miles NE of Mand, about 1,200 ft. (no. M 95); Rodkan (W. Kolwa) about 85 miles E. of Turbat, about 1,800 ft. (M 95B); Nag (W. Kolwa) about 83 miles N. of Turbat, about 2,300 ft. (no. M 239) ; Rar Kaur, 165 miles S. by W. of Kalat, about 3,500 ft. (no. 299). Fl. and fr. in March and April 1918, in Sept. 1917.
Vern. Name : Cheink (Bal.). Seems to be a sort of generic name.

Argyrolobium *sp.* Loc. : Rari Dan, 170 miles S. by W. of Kalat, 2,300 ft. (no. 291) ; Siman river, 15 miles SE. of Khozdar, about 3,700 ft. (no. 360). Fl. in Sept. 1917. *Vern. Name* : Chevid (Br.).

ONONIS *L.*

Ononis sp. Loc. : Benn Chah, 21 miles N. of Surah, about 6,200 ft. (no. M 386).

TRIGONELLA *L.*

Trigonella near uncata *Boiss. & Noe Diagn. ser. II, II, 12.* Loc. : Sarchib, about 62° 40′ E, 26° 16′ N. about 1,900 ft. (no. M 117) ; Mohtaji Kand, about 22 miles SW. of Panjgur, about 2,800 ft. (no. M 117B) ; Panjgur, about 3,100 ft. (no. M 117C.). Fl. in March 1918. *Vern. Name* : Shims (Bal.), Goki Shimsh (Bal.).

MEDICAGO *L.*

Medicago tribuloides *Desr. in Lam. Encycl. III. 635.* Loc. : Sarchib (no. M 117A) ; Chib 63° 8′ E. 26° 19′ N. about 1,600 ft. (no. M 117) ; Wahir, 25 miles W. of Khozdar, about 4,200 ft. (no. 331A). Fl. and fr. in March 1918, Oct. 1917. *Vern. Name* : Shimsh, Goki Shimsh (Bal.), Marav, Merav (Br.). Note : Our specimens have strongly emarginate mucronate leaflets, dentate at the tip. Boissier does not mention this.

Medicago denticulata *Willd. Sp. III, 1414.* **var. lappacea** *Boiss. Fl. Or. II. 103.* Loc.: Panjguri, about 3,100 ft. (no. M 117D). Fl. and fr. in March 1918.
Vern. Names: Goki Shims (Bal.), Mena (Sind.).

Medicago sativa *L.*—Lucerne. Loc.: Quetta. Fl. in August.

Medicago sp. near praecox *DC. Cat. Monsp. 123.* Loc.: Hazarganji, 27° 28′ N, 66° 12′ E, about 3,600 ft. (no. 331). Fl. in Sept. 1917. *Vern. Names*: Shims (Bal.), Marav (Br.).

Madicago sp. Loc: Nagak (W. Kolwa), near mouth of Hodal Pass, about 87 miles E. by N. of Turbat, about 2,400 ft. (no. M 117E). Fl. in April 1918. *Vern. Name*: Goki Shims (Bal.).

Medicago sp. near coronata *Lam. Dict. III, 634.* Loc.: Hazarganji, 27° 28′ N, 66° 12′ E., about 3,600 ft. (no. 332). Growing in a partially flooded meadow. Fl. and fr. in Sept. 1917.
Vern. Name: Shims (Bal.).

MELILOTUS *Turnef.*

Melilotus alba *Desr. in Lam. Dict. I, 63.* Loc.: Panjguri (M 338, M 338A). Fl. in June 1918. *Vern. Names*: Shams (Bal.), Jangli Meni (? Sind.). Uses: Leaves eaten as a vegetable.

Melilotus indica *All. Fl. Pedem. I (1785) 308.* Loc.: Panjguri, about 3,100 ft. (no. M 158, M 145), Nagak (W. Kolwa) about 87 miles E. by N. of Turbat, about 2,400 ft. (no. M. 158A). Fl. and fr. in March and April 1918. Uses: This plant is eaten by man, cooked as a vegetable. *Vern. Names*: Mardumi Shims (Bal.). Madi Shims.

TRIFOLIUM *L.*

Trifolium fragiferum *L. Sp. Pl. 1086.* Loc.: Kalat, about 6,350 ft., plentiful on the edges of irrigated lands (no. M 307A); Iskalku, 7 miles E. of Kalat, 7,500 ft., grows on edges of irrigation channels (no. 10, 10 C); Surab, 43 miles S. of Kalat, 5,750 ft. (no. 103, M 370), grows by water with clover. Fl. in June 1918, Aug. 1917. *Vern. Name*: Jaghar Kirm (Br.), this name comes from the idea that if sheep eat it they get worms in the liver. Horses suffer no harm.

DORYCNIUM *Tourn.*

Dorycnium villosum *Blatt. and Hall. spec. nov.* Herba perennis, villoso-hirsuta, a basi lignosa et ramosa; caules ascendentes, sulcati, foliosi, internodiis brevibus. Folia subsessilia. Petiolus simul cum rhachide 3 mm longus, fortis, sulcatus. Foliola 4, quorum unum terminale, duo terminali proxima et unum in parte inferiore. Petioluli breves sed distincti, graciles. Foliola spathulato-cuneata, mucronata, 10 mm longa, 3 mm lata in parte latissima, parce hirsuta vel glabrescentia in facie superiore, densissime villoso-hirsuta in facie inferiore. Pedunculi erecti, foliis aequilongi, umbellatim 2-3-flori, bractea unica dimidiam partem folioli attingente. Pedicelli 1-2 mm longi. Calyx subaequaliter 5-fidus, dense hirsutus, lobis subulatis, tubo aequilongis in flore, elongatis in fructu. Corolla parum exserta, flava; vexillum apice rubrum? longius caeteris petalis; carina acuta (sed non

rostrata). Legumen 13 mm attingens, cylindricum, turgidum, apice breviter cuspidatum, divisum septulis transversis, glabrum, suturis prominentibus, valvis rugosis. Semina orbiculata, parum compressa, glabra, atro-olivacea. Nota: Species Dorycnii hucusque observatae habent carinam obtusam, nostra autem acutam. Haec differentia non est ratio sufficiens cur nova species excludatur a genere Dorycnii. Nullo modo potest includi sub genere Loti, cum carina careat rostro. Loc.: Hills near Ispikan, about 20 miles NE of Mand, about 1,200—1500 ft. (no. M 89, M 89 A). Fl. and fr. in March 1918. *Vern. Name*: Meshkah (Bal.).

LOTUS *L.*

Lotus tenuifolius *Reichb. Fl. exc. 506.* Loc.: Surab, 28° 29′ N. 66° 16′ E., about 5,700 ft. (no. 105, M 369). Fl. in June 1918, Aug. 1917.—Fr. in Aug. 1917. Note: The flowers range from pure yellow through orange to bright red.

CYAMOPSIS *DC.*

Cyamopsis psoralioides *DC. Prodr. II, 216.* Loc.: Nal, 27° 41′ N, 66° 13′ E. 3,834 ft., probably self sown from some garden (no. 336); Gaz, 18 miles N. of Ornach, about 3,500 ft. (no. 323). Fr. in Sep. 1917. *Vern. Name*: Metli:(Br.).

INDIGOFERA *L.*

Indigofera paucifolia *Del. Fl. D'Eg. (1812) 251.* Loc.: Rodkan (W. Kolwa), about 85 miles E. of Turbat, about 1,800 ft.; Zahren Kahur, 16 miles N. of Pasni, about 200 ft. (no. M42, M42A). *Vern. Names*: Lantu, Timer (Bal.), Hudish (Br.).

Indigofera paucifolioides *Blatt. & Hall. spec. nov.* Suffrutex gracilis, argenteo-canescens in omnibus partibus floribus exceptis, ramis gracilibus. Internodia ca. 3 cm longa. Folia pinnatim 3-foliolata, stipulis annulum scariosum formantibus circumcingentem ramum. Petiolus circa 6 mm longus, rhachis 2-3 mm, persistens, quasi spinescens. Foliola elliptica vel elliptico-lanceolata, subacuta, alterna, terminale longissimum. Racemi axillares, 5-6 cm longi, 5-10-flori, laxi, bracteis minutissimis, pedicellis 1½ mm longis, fortibus, patentibus. Flores 13 mm attingentes. Calyx tubulosus, 7 mm longus, dense adpresse hirsutus, oblique 5-dentatus, dentibus subulatis subaequalibus in parte anteriore, sinu profundo rotundato in parte dorsali. Corolla multum exserta; carina necnon alae vexillo breviores. Legumen non vidimus. Differt ab Indigofera paucifolia floribus minus numerosis sed multo longioribus, forma stipularum. Loc.: Wad, 27° 20′ N., 66° 20′ E., about 4,000 ft. (no. 226 B). Fl. in Oct. 1917.

Indigofera Houer *Forsk. Fl. Aegypt.-Arab. (1775) 137.* Loc.: Near Sorki Chah, Pirandar, about 205 miles SSW of Kalat, about 1,900 ft. (no. 254). Fl. and fr. in Sept. 1917. *Vern. Name*: Niltako (Bal.).

TEPHROSIA *Pers.*

Tephrosia purpurea *Pers. Syn. Pl. II (1807) 329.* Loc.: Pirandar, 205 miles SSW of Kalat, about 1,900 ft. (no. 263); Sor (Kilkaur), about 74 miles S. of Panjgur, about 2,300 ft. (no. M 9G); Dokop,

60 miles W. of Turbat, about 700 ft. (no. M9); Pump, 46 miles W. of Turbat, about 600 ft. (no. M63); 5 miles N. of Mand, about 1,000 ft. (no. M 9E); Ispikan, 16 miles NE. of Mand, about 1,050 ft. (no. M 9F); Awaran, (Kolwa), 26° 24′ N., 65° 12′ E. about 1,750 ft. (no. M 9H). Fl. and fr. in March 1918, Sept. 1918, Dec. 1917. *Vern. Names*: Matkinaok (Bal.), Sanamaki (Kechi Bal.). Note: The flowers show a great range of colour, the most common being a sweet-pea pink with a tinge of blue, but others are very bright chrome red; white seems to be very uncommon. This species is very variable, so much so that we cannot retain Baker's varieties in Hook. f. Fl. Brit. Ind. II, 113.—It is for the same reason that we combine Tephrosia Apollinea Link. Enum. Hort. Berol. II (1822) 252, with Tephrosia purpurea Pers. There is not one character in the diagnosis of T. Apollinea which may not be observed in some specimen of T. purpurea.

Tephrosia *sp.* Loc.: Dokop, 10½ miles E. of Mand, about 650 ft. (no. M 69); Kulbar valley, some 25 miles ENE of Mand, about 1,300 ft. (no. M 107).

Calophaca *Fisch.*

Calophaca tomentosa *Blatt. & Hall. spec. nov.* Herba perennis, villoso-tomentosa, caule subsimplici, tereti, 6 cm alto, folioso a basi, internodiis ca 10 mm longis. Folia 9 cm attingentia, stipulis triangulari-oblongis, integris vel profunde bifidis, cum petiolo connatis, 5 mm longis, petiolo 20-25 mm longo; foliola 11-19, oblonga, obtusa vel retusa, basi rotundata et parum obliqua, 15 mm longa, 6 mm lata, in parte superiore saepe latiora. Pedunculi axillares, 5-8 mm longi, fortes, umbellatim 1-2 flori, bracteis minutis, setaceis, hirsutis. Pedicelli ca 5 mm longi, bracteolis duobus circa medium. Calyx tubulosus, 12 mm longus, inaequaliter 5-dentatus, sublabiatus, dentibus superioribus altius connatis, dente infimo brevissimo, in fructu fissus. Petala 15 mm longa, longitudine subaequalia; carina ad apicem valde rotundata, ampliata et repente incurvata. Stamina diadelphia. Stylus apice incurvus, glaber, stigmate terminali capitato. Legumen immaturum 4 cm latum, lineari-compressum, dense villoso-tomentosum, rostro recurvo. Loc.: Pahrechi Kaur, 10 miles N. of Ornach, about 3,630 ft. (no. 322). Fl. and fr. in Sept. 1917.

Calophaca parviflora *Boiss. Fl. Or. II, 201.* (Chesneya parviflora *J. & Sp.*) Loc.: Mitasing, about 17 miles ESE of Panjguri, about 4,000 ft. (no. M 319); Panjguri, about 3,100 ft. (no. M 319 A). Fl. in May 1918. *Vern. Name*: Mesho (Bal.).

Caragana *Lam.*

Caragana ulicina *Stocks in Hook. Journ. IV. 145.* Loc.: Hushtar Rahi Kaur, about 160 miles S. of Kalat, up to about 4,000 ft. (no. 37 B); very common on both sides of the pass. Fl. in Sept. 1917. *Vern. Names*: Siahchob (Bal.), Hajipit (Br.).

Caragana ambigua *Stocks in Hook. Journ. IV. 145.* Loc.: Harboi, 18 miles ESE of Kalat, 9,000 ft. (no. 19; Benncah, 21 miles N. of Surab, about 6,200 ft. (no. M 386). *Vern. Name*: Sipit (Br.),

Chidirk, " which is properly the name of the babul, which is not found up here (Harboi)." Uses: It is good for firewood and goats eat it.

Caragana sp. Loc.: Rar Kaur, 165 miles S. by W. of Kalat, up to about 4,000 ft. (no. 37A).
Vern. Names: Siahchob (Bal.), Hajipit (Br.).

GLYCYRRHIZA *L.*

Glycyrrhiza glabra *L. Sp. Pl. 1048* var. **glandulifera** *Reg. & Herd.* Loc.: Pusht Kuh (Kharan), about 26° 57′ N, 65° 10′ E, about 3,500 ft. (no. M 300, M. 300 A). Uses: The root is said to be good for sore throats. When chewed it has a not unpleasant rather sweet flavour, somewhat like that of an uncooked green pea. It is also mixed with other drugs for derangements of the blood. (Hotson).
Vern. Name: Washdar (Bal.).

ASTRAGALUS *L.*

Astragalus tribuloides *Del. Ill. Eg. 22.* Loc.: Manguli, 26° 45′ N, 65° 21′ E, about 2,600 ft. (M. 269 B); near Kuldan, about 85 miles E. by N. of Turbat, about 2,400 ft. (no. M 233). Fl. and fr. in April 1918. *Vern. Name*: Kahurkah (Bal.).

Astragalus Stocksii *Benth. in Herb. Kew et Bunge Astr. 5.* Loc.; Junction of Raghni and Sichk rivers (Kharan), about 3,600 ft. (no. M 122A): Mantar Juzhaf, about 40 miles S. of Panjgur, about 3,200 ft. (no. M 202); Gili, about 10 miles W. of Chib, about 1,650 ft. (no. M 122); near Shahdadzai, 42 miles S of Kalat, 5,100 ft. (no. 132 A): near Sitani, 59 miles S. of Kalat, 5,300 ft. (no. 132). Fl. in April 1918, Aug. 1917. Uses: A very good camel-grazing bush. *Vern. Names*: Shinilok (Bal., Br.), Shinilo, Shinalok (Bal.), Shenelo (Br.).

Astragalus polemius *Boiss. Fl. Or. II, 306.* Loc.: Near Ornach, about 3,300 ft. (no. 311); Siman river, 15 miles SW. of Khozdar, about 3,700 ft. (no. 311A). *Vern. Name*: Bakhmal (Br.).

Astragalus strobiliferus *Royle Ill. 199.* Loc.: Harboi, 18 miles ESE of Kalat, 9,000 ft. (no. 32). Grows in thick close spiny clusters, a few inches high. Uses: Eaten by sheep. *Vern. Name*: Pith (Br.).

Astragalus sp. Loc.: Harboi, 18 miles ESE of Kalat, 9,000 ft. (no. 39.) Grows in thick masses a few inches high. Uses: Eaten by sheep, camels, etc. *Vern. Name*: Gird Pith (Br.).

Astragalus sp. Loc.: Harbud, about 55 miles E. of Panjgur, 3,700 ft. (no. M 269 C). Fl. in April 1918.
Vern. Names: Kahurbahar (Bal.), Kandiko (Br.).

TAVERNIERA *DC.*

Taverniera nummularia *DC. Mem. Leg. 339, tab. 52.* Loc.: Korak (Pelar), 180 miles S. by W. of Kalat, 1,900 ft. (no. 226 A); Turbat, about 600 ft. (no. M 4); N. E. of Hoshap, about 60 miles ENE of Turbat, about 2,000 ft. (no. M 35); Garrok, 32 miles N. of Pasni, about 350 ft. (no. M 4 B); below Gajar, 165 miles SSW of Kalat, about 3,450 ft. (no. 226); Hodal Pass (S. side) about 85 miles S. of Panjgur, 2,900-2,400 ft. (no. M 4 C). Fl. in Feb. 1918, Sept. 1917. *Vern. Names*: Hudish, Lantu (Bal., Br.).

Taverniera Stocksii *Boiss. Fl. Or. II, 509.* Loc.: Kaurdat, 10 miles N. of Rekin, about 1,900 ft. (no. M 4 D); Pirandar, about 205 miles SSW of Kalat, about 1,900 ft. (no. 252); Korak (Pelar), 180 miles S. by W. of Kalat, 1,900 ft. (no. 271). Fl. in Sep. 1917. *Vern. Name*: Siahbar (Br.).

Taverniera glabra *Boiss. Diagn. ser. I, II, 90.* Loc.: Ispikan, 16 miles NE of Mand, about 1,050 ft. (no. M 75); Gajar 165 miles SSW of Kalat, 3,450 ft. (no. 227); hills S. of Chambar (Kolwa), 26° 9′ N, 64° 42′ E. 1,800—2,200 ft. (no. M 75 A). Fl. in March and April 1918, Sept. 1917. *Vern. Names*: Latug, Lantu (Bal.).

Taverniera sp. Loc.: Ispikan, 16 miles NE of Mand, about 1,050 ft. (no. M 80); Karki 21 miles ENE of Buleda, about 1,600 ft. (M 128); Gwambuk, about 60 miles S. by E. of Panjgur, about 2,700 ft. (no. M 211).

Ebenus *L.*

Ebenus erinacea *Jaub. and Sp. Ill. Or. tab. 255.* Loc.: Hills near Ispikan, about 20 miles N. of Mand, about 1,200—1,500 ft. (no. M 96). *Vern. Name*: Sag-I-Dantal (Bal.). Note: We have separated Ebenus erinacea from E. stellata Boiss. Jaubert and Spach's illustrations bring out the differences between the two species sufficiently.

Alhagi *Desv.*

Alhagi camelorum *Boiss. Diagn. ser. I, IX, 114.* Loc.: Panjgur (no. M 62 C); Tump, 46 miles W. of Turbat, about 600 ft., very common all over the country (no. M 62); Mohtaji Kand, about 22 miles SW. of Panjgur, about 2,800 ft. (no. M 62 A); Sitani, 59 miles S. of Kalat, 5,300 ft. (no. 121); Quetta; Mazarjuh, about 28° 11′ N, 66° 2′ E., about 5,200 ft. (no. M 62 D). Fl. in May and June 1918.—Fr. in June and Aug. 1918. *Vern. Names*: Shinz (Bal., Br.).

Vicia *L.*

Vicia angustifolia *Roth Tent. I, 310.* Loc.: Panjgur (no. M 147 A). Fl. and fr. in March 1918.
Vern. Names: Mashuk (Bal.), Mashuka (Sind.).

Vigna *Savi.*

Vigna catiang *Walp. in Linnaea XIII (1839) 533.* Loc.; Lukh, 100 miles S. of Kalat, 4,300 ft. (no. 178.). Fl. in Aug, 1917.

Rhynchosia *Lour.*

Rhynchosia minima *DC. Prodr. II, 385.* Loc.: 3,500 ft. downwards, exact locality not given (no. 393 B). Fl. and fr. in Oct. 1917. *Vern. Name*: Wal.

Rhynchosia minima *DC.* var. **laxiflora** *Baker in Hook. f. Fl. Brit. Ind. II.* 223. Loc.: Near Ornach, about 3,000 ft. (no. 320). Fl. and fr. in Sept. 1917. *Vern. Name*: Shanmazar.

Dalbergia *L. f.*

Dalbergia sissoo *Roxb. Hort. Beng. 53.* Loc.: Zidi, 15 miles ESE of Khozdar, about 3,600 ft. (no. 294 A).
Vern. Names: Jag (Bal. Br.), Tali (Sindhi).

Dalbergia latifolia *Roxb. Cor. Pl. II, 7, t.* 113. Loc.: Rar Kaur, 165 miles S. by W. of Kalat, about 3,500 ft. (no. 294.)
Vern. Names: Jak (Bal.), Jag (Br.Bal.).

Sophora *L.*

Sophora Griffithi *Stocks in Hook. Journ. IV (1852) 147.* Loc.: Hills about 35 miles SW. of Panjgur, about 2,800 ft. (no. M 130); hills S. of Chambar (Kolwa), 26° 9′ N., 64° 42′ E. about 2,160 ft. (no. M 255); Pusht Kuh, about 26° 57′ N., 65° 12′ E. about 3,500 ft. (no. M 130 B). Teghab., 107 miles S. of Kalat, 4,150 ft. (no. 16A); Harboi, 18 miles ESE of Kalat, 9,000 ft (no. 16): sandy ground and the edges of dry sandy river beds at Siahen Camb, about 36 miles E. by S. of Panjgur, about 3,800 ft. (no. M130C). Fl. in March 1918, Aug. 1917.—Fr. in April 1918. *Vern. Names*: Shampashtir (Br., Bal.), Shampashtig (Kechi Aal.), Shampachir (Panjguri Bal.), Shamkastir.

Sophora alopecuroides *L. Sp. Pl. 373.* Loc.: Kalat, between 6,350—7,000 ft. (no. 92, M 39 A). Fl. and fr. in July 1918. Uses: Used as a green manure for melons, being buried under the young plants. *Vern. Name*: Basunduk (Br.).

Parkinsonia *L.*

Parkinsonia aculeata *L.* Loc.: Gajar, 165 miles SSW of Kalat, 3,450 ft. (no. 233), growing in a garden.
Vern. Name: Vilayati Babar (Bal.),

Cassia *L.*

Cassia obovata *Collad. Mon. 92.* Loc.: Pirandar, about 205 miles SSW of Kalat, about 1,900 ft. Fl. and fr. in Sept. 1917.

Prosopis *L.*

Prosopis spicigera *L. Mant. 68.* Loc.: Near Bazdad, 25 miles E. of Chambar, Kolwa, about 1,850 ft. (no. M 279); below Bhani, 131 miles SSW of Kalat, about 3,800 ft. (no. 209). Very common. *Vern. Names*: Kahur (Bal.), Mar (Br.), Kandi (Sind), Kikar (Urdu).

Acacia *Willd.*

Acacia arabica *Willd. Sp. Pl. IV (1805) 1085.* Loc.: Andrabedi river, about 42 miles N. of Las Bela, about 3,500 ft. *Vern. Names*: Chidirg (Bal. Br.), Chidrik (Br.), Hari Babar (Sind.)

Acacia Jacquemontii *Benth. in Hook. Lond. Journ. I (1842) 499.* Loc.: Nasirabad, 23 miles W. of Turbat, about 400 ft. (no. M 57). Fl. in March 1918. *Vern. Name*: Chigird Chidirg (Bal.).

Acacia Senegal *Willd. Sp. Pl. IV (1805) 1077.* Loc.: Near Kanoji, 47 miles N. of Las Bela, about 3,200 ft. (no. 377).
Vern. Name: Khor (Br.).

Albizzia *Durazz.*

Albizzia Lebbek *Benth. in Hook. Lond. Journ. Bot. III (1844) 87.* Loc.: Basunkani springs, about 38 miles N. of Las Bela, about 2,900 ft. (no. 394). This tree becomes common as one goes S. from here. Many trees at Las Bela. *Vern. Name*: Siri (Br.).

Rosaceae

PRUNUS *L.*

Prunus brahuica *Aitch. and Hemsl. in Trans. Linn. Soc. ser. 2, Bot. III, 62.* Loc.: Near Sitani, 59 miles S of Kalat, 5,300 ft. (no. 130).

Prunus oburnea *Aitch. and Hemsl. in Trans. Linn. Soc. ser. 2, Bot. III, 62.* Loc.: Dokop, 60 miles W of Turbat, about 700 ft. (no. M 15); Kaur Dat, 10 miles N of Rekin, about 1,900 ft. (M 15C); Harboi, 18 miles ESE of Kalat, 9,000 ft. (no. 20). Uses: Men, animals and birds eat the fruit.
Vern. Names: Jogar (Bal., Br.), Mozhmonk (Br.).

Prunus *sp.* Loc.: Harboi, 18 miles ESE of Kalat, 9,000 ft. (no. 37). *Vern. Name*: Siahchob.

PYRUS *L.*

Pyrus cordata *Desv. Obs. Pl. Anj. 152.* Loc.: Panjgur, about 3,100 ft. (no. M 153). Fl. in March, 1918.

ROSA *L.*

Rosa anserinaefolia *Boiss. Diagn. ser. I, VI, 51.* Loc.: Harboi, 18 miles ESE of Kalat, 9,000 ft. (no. 15). Fl. in August, 1917. *Vern. Name*: Atishi Gulab.

Onagraceae

EPILOBIUM *L.*

Epilobium hirsutum *L. Sp. Pl. 494.* Loc.: Khozdar, 27° 48′ N, 66° 37′ E, about 4,100 ft., near irrigation channels (no. 343). Fl. and fr. in September, 1917. *Vern. Name*: Sorphul (Bal., Br.).

Epilobium parviflorum *Schreb. Spic. 146.* Loc.: Zidi, 15 miles ESE of Khozdar, about 3,600 ft. (no. 343A). Fl. in September, 1917. *Vern. Name*: Sorphul (Bal.).

Epilobium minutiflorum *Hausskn. in Oestr. Bot. Zeitschr. XXIX (1879) 55.* Loc.: Harboi springs, 18 miles ESE of Kalat, 8,600 ft. (no. 67). Fl. and fr. in August, 1917. Uses: The seeds are soaked to make a sharbot, which is drunk both for pleasure and to cure head aches. *Vern. Name*: Rush (Br.).

Cucurbitaceae

CUCUMIS *L.*

Cucumis trigonus *Roxb. Hort. Beng. (1814) 70.* Loc. W. side of Burida Pass, 140 miles SSW of Kalat, under 4,250 ft. (no. 216); near Sorki Chah, Pirandar (no. 273). Fl. in August, 1917.
Vern. Name: Wal (Br., Bal.).

Cucumis melo L. *Sp. Pl. (1753) 1011*, var. *agrestis* Naud. in Ann. Sci. Nat. ser. 4, XI (1859) 73 and XII, 110. Loc. Las Bela, about 700 ft. (no. 324A); Jebri, 247 miles SSW of Kalat, 3,850 ft. (no. 225); Garruk, 27 miles N of Ornach, about 3,400 ft. (no. 324); Korak (Pelar), 180 miles S by W of Kalat, 1,900 ft. (no. 267). Fl. in August,

September and October, 1917. *Vern. Names*: Chibit (Br.), Chibid (Sindhi), Wal (Bal. Br.), Girat Wal (Br.).

Cucumis prophetarum L. *Cent. Amoen. Acad. IV (1759) 295.* Loc.: Pirumar, 16 miles S of Khozdar, about 4,100 ft. (no. 364). Fr. in September, 1917. Uses: The fruit is said to cause instant vomiting, and to be used medicinally for that purpose. *Vern. Name*: Het Chibit.

CITRULLUS *Neck.*

Citrullus colocynthis *Schrad. in Linnaea XII (1838) 414.*

Loc.: Near Manguli, 197 miles SSW of Kalat, about 2,450 ft. (no. 243); Teghab, 107 miles S of Kalat, 4,150 ft. (no. 186); Chhuttok, 90 miles S of Kalat, 4,500 ft. (no. 173); Rek. Chah, 11 miles E of Chambar (Kolwa, about 1,800 ft. (no. M 267). Fl. in August and September, 1917.—Fr. in August, 1917.
Vern. Names: Hinjiri (Bal.), Kiringli (Br.), Kulkushtag (Bal.); Tarbuzah-abu-Jir Hagara, Persian, Gunj (Kechi Bal.).

COCCINIA *W. & A.*

Coccinia indica *W. and A. Prodr. (1834) 347.* Loc.: Korak (Pelar), 180 miles S by W of Kalat, 1,900 ft. (no. 275); Audrabedi river, 42 miles N of Las Bela, Diria Gadha 35 miles N of Las Bela, 3,500—2,500 ft. (no. 393). Fl. and fr. in September, 1917.
Vern. Name: Wal. (Bal., Br.).

MELOTHRIA *L.*

Melothria maderaspatana *Cogn. in DC. Monogr. Phan. III (1881) 623.* Loc.: Pirandar, 205 miles SSW of Kalat, about 1,900 ft. (no. 258). *Vern. Name*: Wal (Bal., Br.).

CORALLOCARPUS *Welw.*

Corallocarpus epigaeus *C.B. Clarke in Hook. f. Fl. Brit. Ind. II, 628.* Loc.: Der river, 38 miles N of Las Bela (no. 393 F). Fr. in October, 1917. *Vern. Name*: Wal (Bal., Br.).

Ficoideae.

TRIANTHEMA *L.*

Trianthema monogyna *L. Mant.* 69 Loc.; Rek Chah, 11 miles E of Chambar, Kolwa, about 1,800 ft. (no. M 270); Goshamag, about 16 miles E of Chambar, Kolwa, about 1,850 ft. (no. M272); Jebri, 137 miles SSW of Kalat, 3,775 ft. (no. 117A). Fl. and fr. in April, 1918, August, 1917. *Vern. Names*: Lipchanko, Uwalu (Bal.), Surinchk (Br.).

Trianthema pentandra *L. Mant. 79.* Loco.: Tharrav, about 32 miles S of Wad, about 3,800 ft. (no. 382); Kurak (Pelar), 180 miles S by W of Kalat, 1,900 ft. (no. 278); Zid, 15 miles ESE of Khozdak. about 3,600 ft. (no. 354). Fl. and fr. in September and October 1917. *Vern. Name*: Khisun Vel (Br.).

ORYGIA *Forsk.*

Orygia decumbens *Forsk. Fl. Aegypt.-Arab. 103.* Loc.: Kanoji, 47 miles N of Las Bela, about 3,900 ft. (no. 384). Fl. and fr. in. October, 1917.

(To be continued.)

CURRENT LITERATURE.

Histology.

Harper, R. A. The structure of protoplasm. *Am. Jour. Bot. 6 (1919) pp. 273—300.*

A quarter of a century ago there was much speculation regarding the physical structure of protoplasm. It was then expected that better fixation, better staining processes, and more accurate microscopic observation would reveal this structure. Since then there has been much evidence accumulated bearing on the problem, though there has been little attempt to formulate rigid theories of the structure of protoplasm.

Professor Harper of Columbia University, in an address before the Botanical Society of America in 1917, has brought to bear on the problem what he considers to be the most important evidence from recent work in cytology, in the chemistry of the colloidal state, and in genetics. He points out that evolution has been along the lines of specialization of cells groups and division of labour between cells, rather than by any change in fundamental cell organization.

He considers that the most significant evidence from cytology is the recognition of differentiated areas within the protoplasm, within which specific processes are carried on. Examples are elaioplasts or fat-forming bodies, plastids of various kinds, vacuoles, and chromosomes. In many of the lower plants the chloroplasts appear not to have a definite limiting membrane like a plasma membrane, but are more or less vaguely restricted regions of the protoplasm impregnated with chlorophyll. With increasing localization of position and specialization in function, these protoplasmic areas finally become permanent and self-perpetuating. Chromosomes, for instance, always arise from pre-existing chromosomes by an astonishingly complicated and precise division. He believes that "the bulk of the literature of the plant chondriosome is a mere tabulation of the appearance of variously fixed and colored particles in the cell body with the hope that such bodies may later be found to be specific and fundamentally significant." The concept of localized areas of protoplasm for specific function would include all the organs of the cell, temporary as well as permanent.

Perhaps the most important evidence from recent chemistry of the colloidal condition is the "recognition of the fact that the units of colloidal systems, especially those of proteins, carbohydrates, etc., are large enough to be distinguishable at least with our present microscopes". Protoplasm is a colloidal substance, often thought of as a simple two-phase system with water or some other non-living substance as one of the phases. BUTSCHLI considered it to have an alveolar structure, with the living substance forming the continuous walls and the non-living occupying the vacuoles; BEIJERINCK and others conceived of protoplasm as made up of granules of living substance distributed through a non-living matrix. Interpreted in terms of a colloidal solution the first theory would make the continuous phase the more important, while the second would make the disperse phase the more

important. Doubtless protoplasm may change from one condition to the other in response to changing conditions.

But protoplasm certainly is not so simple as a simple two-phase colloidal system. The present theory of colloids allows for the possibility of one colloidal system containing other more or less differentiated systems. "The cell must at least be conceived as a complex of such colloidal systems, some possibly simple two-phase systems . . . some polyphase . . ." Such a conception would account for the presence of localized areas in which special processes are carried on. The surface tension membranes between the various constituents would hinder diffusion between the different regions of the cell, would make possible the maintainance of the various structures and organs of the cell which the microscope reveals, and would permit widely diverse processes to go on simultaneously within the same cell.

Genetics and the structure of protoplasm. Some sort of serial arrangement of hereditary factors in the chromosomes theoretically appears best to fit the facts of chromosome reduction and segregation of factors. From a few accurate records of size and volume of chromosomes, and from measurements that have been made of the size of various molecules, there appears to be plenty of room in chromosomes for a number of molecules "equal to the most extreme demands of the factorial hypothesis, if each factor can be represented by a single molecule or even a group of molecules."

WINFIELD DUDGEON.

Mottier, David M. Chondriosomes and the primordia of chloroplasts and leucoplasts. *Annals of Botany XXXII (1918) pp. 91-114. 1 pl.*

Chondriosomes (mitochondria) were discovered in plant cells by Meves in 1904. Since then a great deal of research has led to the conclusion that they are very numerous in the cytoplasm; that they are practically universally present in plant cells; and that they are almost certainly permanent cell organs, being transmitted from one cell generation to the next along with the cytoplasm. Some have claimed that they become transformed into plastids of various kinds, while others hold that chondriosomes and the bodies which develope into plastids are quite distinct. It has been found that some of the most commonly used killing and fixing reagents, especially acetic acid, destroy chondriosomes, and this fact probably accounts for their late discovery.

Mottier used as a fixing solution

1% chromic acid	17 cc.
2% osmic acid	3 cc.
glacial acetic acid	3 drops

and stained with either a modification of Benda's crystal violet method or iron-alum-haematoxylin. He worked with root tips of *Pisum sativum*, *Zea mays*, and *Adiantum pedatum;* thalli of *Marchantia polymorpha*, *Anthoceros laevia*, and *Pallavicinia;* seedlings of *Pinus Banksiana;* and stem and leaves of *Elodea canadensis*. *Pisum* proved to be the most satisfactory material for study.

When properly fixed and stained, the meristem cells of the root-tip of *Pisum* show a large number of small but quite conspicuous bodies of two distinct kinds scattered through the cytoplasm: some are larger, straight or variously bent rods of varying length and thickness; others are very small granules occurring singly or in chains, or delicate slender

straight or curved rods, also of varying length and thickness. Both kinds multiply by transverse division. Passing from the meristem to the older cells of the root, some of the larger rods begin to grow, and enlarge at one or more points, and finally become plastids with starch grains in the enlargements; those that do not become plastids at length disorganize. The minute rods and granules persist practically without change in size, form, and number as the cells grow older. He calls the larger rods "primordia of plastids", and restricts the term chondriosomes to the minute bodies.

Zea mays, *Adiantum*, *Pinus* seeding, and *Elodea* gave similar results. In *Marchantia* both plastids and their primordia are present in all vegetative cells, but chloroplasts are early eliminated from spermatogenous tissues and only the chondriosomes remain. It has been suggested that chondriosomes are the remains of disintegrated plastids. *Anthoceros* furnishes valuable evidence on this point, since each cell contains but one chloroplast. The author finds chondriosomes present in large numbers in all cells; they are just as numerous in cells with healthy normal chloroplasts as in those in which the chloroplasts appear abnormal. This disposes of the plastid origin of chondriosomes.

The conclusion is that chondriosomes and the primordia of plastids are quite distinct, and are fairly easily distinguished by their difference in size, even though they show the same staining reactions. Much of the confusion in earlier writings has been due to failure to recognize this fact. He thinks "We are now justified in the view that leucoplasts, chloroplasts, and chondriosomes are organs of the cells, of the same rank as the nucleus", and that if this be true, "these bodies must be transmitted from individual to individual in the form of their primordia, and that chromatin is not the sole carrier of hereditary characteristics". "To claim that certain phenomena of fluctuating variability and other numerous characteristics, Mendelian or otherwise, owe their appearance and transmission to the primordia of plastids and chondriosomes may be a daring hypothesis, but, if as there is good reason to believe, these bodies are permanent organs, there is no escape from some such assumption.

The reader is left with the feeling that the work has been carefully and thoroughly done, and that the conclusions are convincing.

W. D.

Some New Laboratory Methods.

Gussow, H. T. A new method for "hanging drop" cultures. *Phytopathology 8*; (*1918*) *p. 447.*

Instead of the usual drop suspended from the under side of a coverglass, the author recommends that the drop be flattened out into a thin film by means of a smaller coverglass placed over it. This keeps the culture in a thin layer, and permits examination of all parts with the highest powers of the microscope.

Bachman, Freda M. A bacteriological method useful for the study of other microorganisms. *Am. Jour. Bot. 5 1918 pp. 32-35.*

Ordinary methods of the culture of bacteria are adapted so that the cultures may be grown on microscopic slides and made into permanent preparations. Bacteria when grown on a slide in a thin film of hard nutrient medium retain their normal position in the colony. The method has been

found valuable for the study of yeasts. Hard potato agar (potato broth with 3 % agar and 2 % dextrose) is carefully cleared and stored in test tubes. When wanted for use, the agar is barely melted, and inoculated with a thick culture of yeast. A small drop of the suspension is spread evenly over a chemically clean warm slide, then incubated in a damp chamber at favourable temperature. When the colonies of yeast have reached the desired stage of development, they are killed and stained by any of the standard methods. Great care must be exercised to prevent the agar film from floating off the slide. In practice it is better to leave one end out of the solutions so that the agar film may become dry. After staining, the film is dehydrated, cleared, and mounted in the usual manner. The great advantage is that the cells of the colony are retained in their normal position, and are all in one plane

Goodspeed, T. H. Method of replacing paraffin solvent with paraffin. *Bot. Gaz. 66 (1918) pp. 381-382.*

For fine morphological and cytological preparations it is necessary that the material be infiltrated with paraffin very slowly. According to the method of the author, the vial of xylol containing the material is first cooled ; then melted paraffin is poured carefully over the surface. When properly done the paraffin hardens into a well formed plug at the surface of the xylol, and shows no tendency to slip down later. Solution goes on slowly from the bottom of the plug, and infiltrates the material gradually.

Szombathy, Kolomon. Neue Methode zum Aufkleben von Paraffinschnitten (New methods of affixing paraffin sections). *Zeit. Wiss. Mikr. 34 (1918) pp 334-336.*

Sections of many kinds of material are difficult to keep on the slide during the various processes of staining. In the new methods the fixitive is made as follows: dissolve 1 gm. of gelatin in 100 cc. of distilled water at 30° C., add 1 cc. of a 2% solution of sodium salicylate, cool, and filter; then add 15 cc. pure glycerine. Among the various methods for use, probably the most satisfactory is to smear the fixitive thinly on a clean slide, float the paraffin sections out on the slide in a 2% formalin solution, and gently warm on a warming plate to flatten them. Drain off the excess of formalin solution, and dry the slide. The fixitive keeps well, holds very refractory material on the slide even after prolonged washing in water, is not affected by alkalis, and shows little tendency to take up stains.

Otis, Charles H. Labeling of miscroscopical slides in staining technique. *Science N. S. 47 (1918) pp. 219-220*

To avoid the danger of loss or mutilation of labels on slides during staining, the labels may be written at one with an ink made according to the following formula : dissolve 15 gms. of best cabinet maker's glue in 100 cc. of water at low temperature, add excess of potassium bichromate crystals, and expose to strong light for a week ; then filter, and rub in stick India ink to the desired blackness ; store in a tightly stoppered glass bottle. The ink keeps well, is easy to use, and is not affected by the usual reagents. An ordinary pen is used for writing and the slides must be clean.

Gage, Simon H. Hand made lantern slides. *Science N. S. 48 (1918) pp. 221-222.*

Where it is desired to use hand drawings for lantern slides, they may be made quickly and satisfactorily by coating clean lantern plates with a thin

solution of some hard varnish and drawing on the varnish surface with a clean pen and India ink. The slides may be used unbound, or they may be bound in the usual manner for permanence.

Osterhout, W. J. V. and **A. R. C. Haas.** A simple method of measuring photosynthesis. Preliminary note. *Science N. S. 47 1918 pp. 420-422.*

To a large amount of water add a little phenolthalein and sodium bicarbonate till a barely perceptible pink color is developed. Some of the solution freshly made is put into a small tube with a branch of an aquatic plant. When the tube is placed in sunlight the color of the solution soon becomes bright pink, as the result of removal of CO_2 from the water during photosynthesis. Under proper conditions the intensity of the colour may be used to estimate the amount of photosynthesis. If after the color is developed, the tube is kept in darkness for some time, the solution becomes colorless again, due to the liberation of CO_2 by respiration acting alone.

Osterhout, W. J. V. A simple method of demonstrating the production of aldehyde by chlorophyll and by aniline dyes in the presence of sunlight. *Am. Jour. Bot. 5; (1918) pp. 511-513.*

An alcoholic extract of chlorophyll is shaken up with carbon tetrachloride. The carbon tetrachloride solution is then drawn off and sprayed on filter paper. After the paper has become dry it is sprayed again, and the process is repeated till the paper becomes dark green like a leaf. The filter paper is then fitted over the entire inner surface of a large bell jar and wet with water to make it fit and adhere to the glass. The bell jar is put on a glass plate over a large petri dish containing about 5 cc. of water, and the edges are sealed vaseline. The apparatus is placed in full sunlight and left till the chlorophyll has been bleached to a pale green or pale yellow. Then the water is tested by means of Schryver's text for aldehyde, and a positive result usually is obtained.

It is of great interest that certain aniline dyes, as methly-green and iodine-green, in water solution, may be substituted for chlorophyll. It makes little difference whether CO_2 is present or excluded, but the presence of oxygen is necessary. The author concludes "that the aldehyde is not produced by" the decomposition of CO_2 but rather by the decomposition of chlorophyll. It may be that this method of aldehyde formation a regular step in normal photosynthesis.

WINFIELD DUDGEON.

Physiology.

Mallock, A., Growth of Trees, with a Note on Interference Bands formed by Rays at Small Angles. *Proc. Roy. Soc. B 90. (1918) No. B. 627 pp. 186—191 with 4 fig. in text.*

In this paper is described a device for the measurement of the very minute hourly increase in girth of an ordinary tree, by its effect on the interference bands produced by the incidence of mono-chromatic light on a glass plate resting by one edge on a prison and inclined at a small angle to it. A band of invar is passed round the tree, previously smoothed a little, and made to

pass over two rockers, or shallow drums, which actuate the glass plate and prism respectively. The plate carrying the instrument is screwed firmly to the tree, and the variation in the position of the bands observed by a small telescope placed a few feet away. By this means hourly growths of 0'00003 to 0'0003 of an inch can be observed; and measurements made with the instrument, as shown in the diagram for the Oak, Douglas Fir and Black poplar, show that variations in growth are roughly inversely to variations in temperature, the growth being most rapid when the temperature is lowest. The author suggests that this may be due to variations (with temperature) of the rate of evaporation from the leaves coupled with a nearly constant rate of absorption by the roots: and that while the rate of formation of the new wood is represented by the mean line drawn through the diagram of girth, the divergence from this mean represents the degree of turgescence in the bark and the layers immediately underlying it.

The humidity of the air was not observed so the effect of variation in it could not be calculated, but rain had apparently the effect of increasing the girth.

P. F. F.

Stapleton, R. G. and **Adams, Margaret.** The Effect of Drying on the Germination of Cereals. *The Journal of the Board of Agriculture, XXVI, 4, July 1918, pp. 364—381.*

The problem of the life and death of seeds is one that has at various times received considerable attention, but is by no means yet completely solved. Blackman, Ewart, Demoussy and others have enlightened us on various points, and the writers of the article under review treat from a practical standpoint the effect on germination of the drying of the seeds of cereals.

The process of drying (called "conditioning") is used by the miller and the maltster to ensure uniform germination. On the same principle, drying was utilized for the further investigation of unsatisfactory samples of some cereal seeds.

The cereals used were wheat, barley, rye and oats.

It was found that sound seed if sown immediately after thrashing, gives a percentage of germination much lower than that obtained if the same seed is dried artificially or kept without special drying for 2-3 weeks. In the case of unsound seed drying or keeping may cause a decrease in germination percentage. Grain that has been harvested or stacked in bad conditions, and grain that has commenced to sprout are such seed.

The drying given was for three days at 40° C after receipt of the sample. The keeping meant that the gain remained in its sample bag for two to three weeks after receipt.

The reviewer would remark that it would seem as if some kind of "ripening" goes on during the drying or keeping period. We may only guess what this may be. It is worth remembering that dry integuments are, impervious to gases, and that the drier the seed the better does it stand high temperatures. All these facts may have some connection.

Demoussy (Comptes Rendus 1916, 162, 435) held that a seed contains not only a miniature plant, but also a mass of microorganisms that compete with the plant for oxygen, and suggested that some method of partial sterilisation would be useful. Has drying some such effect?

W. Burns.

Stiles, W., and Kidd, F. The influence of external concentration on the position of the equilibrium attained in the intake of salts by plant cells. *Pro. Roy. Soc. B. 90 No. B. 632, p. 448 with graphs.*

The authors have been conducting experiments with slices of living tissues to ascertain the position of equilibrium attained in the intake of individual salts, and allied phenomena. The method adopted is that of placing a certain number of washed thin slices of potato or carrot in different solutions the change in the electrical conductivity of which is taken as a direct measure of absorption, due regard being paid to the exosmosis which may take place at the same time. KCl, NaCl or $CaCl_2$ solutions are normally absorbed, the rate of initial absorption increasing with the concentrations of the solutions employed. Cu So, solution however causes exosmosis in excess of absorption, and thus seems to destory in a way the semipermeability of the cell. This phenomenon is more pronounced if stronger solutions of Cu So_4 are employed. Anomalous phenomena in the case of $AlCl_3$ are hoped to be explained in subsequent articles. The authors have not investigated the mechanism of the cell concerned.

Previous work on the subject conducted by Stiles W., and Jorgensen I., and published in *Ann. Bot. Vol. XXIX and XXXI*, supports the view that the method employed is a correct one. In these papers they discussed Czapek's theory of plasma membrane. It may be remembered that Czapek in 1914, started a theory that the mechanism concerned in the passage of salts is the outermost layer of protoplasm, containing lipoid matter. With reference to this theory they say that his experiments were crude and unscientific and his data wrong, that the rate of exosmosis is not a function of surface tension, and that there is 'not a shred of evidence' in support of some of his assumptions such as the one that since "solutions whose surface tension with air is 0-68 are just strong enough to produce exosmosis from the cell therefore the surface tension of the outermost layer of protoplasm towards air must also be 0-68". So they seriously doubt the verity of his simple theory of plasmolytic membrane as the mechanism in the intake of salts.

Therefore the phenomenon of the absorption of salts seems to be more complex than is usually supposed. It is not a case of mere diffusion.

M. BALASUBRAHMANYAM.

Pathology

Hole, R. S. Plant Diseases. *Indian Forester Vol. XLV (1919) 584,*

Hole is of opinion that of recent years there has been a decided tendency to exaggerate the importance of fungi and to regard them as being the primary cause of most plant diseases. He feels that "if we are to make real progress in controlling the diseases of our forest plants, we must develop and expand the study of œcology, or as it is sometimes termed field physiology, and must regard plant diseases as complex problems frequently requiring for their complete solution the combined efforts of a number of experts, such as œcologists, mycologists and biological chemists." A letter written by the late Mr. Ch. Ogilvie Farquharson and reproduced from the Kew Bulletin, 1918, p. 353, expresses similar views. I quite agree with the opinion substantiated by good reasons, but I should be sorry if the authorities of the Forest Department were to show less interest in the work done by their mycologists.

E. B.

Howard, A., and Howard, G. L. C. The Spike disease of Peach Trees. An example of unbalanced sap-circulation. *Indian Forester, Vol. XLV (1919) 611.*

The paper describes the pathological condition of the peach tree which closely resembles the spike of sandalwood. Morphological differences between normal and spiked plants are to be seen in the foliage, the stems, and the roots. Interesting results were obtained by microscopic examination of affected plants at all stages. The leaves show the presence of starch greatly in excess of the normal, twigs and branches contain "an enormous accumulation of starch in the pith, in the medullary rays in the wood and bast parenchyma and there is a sharp line of demarcation, as regards starch deposition, at the junction of the stock and scion." The chemical composition of the leaves show marked differences. The authors are of opinion that the cause of the spiked condition is to be found in the junction between the stock and the scion, the trouble arising from the prolonged unbalanced sub-circulation resulting from an imperfect junction of the stock and scion. They think that "the problem would appear to be considerably clarified if the sandal is looked upon as a root grafted on to its hosts by means of the haustoria and if the association is regarded as symbiotic rather than parasitic." The fact of the transmission of disease by means of grafting and budding would seem to receive a new proof by the hypothesis suggested by the authors.

E. B.

Fungi

Reinking, Otto A. Phytophthora Faberi *Maubl*: the cause of Coconut bud-rot in the Philipines. *Philipine Journal of Science XIV 1919, pp. 130—150.*

The first authentic and reliable investigations into this disease in the Phillipines were made in 1908, and it was reported to have been prevalent and serious in one place for ten years previously. The diseased parts are always found to be infected with bacteria, especially *B. Coli*, but this is considered as due only to secondary infection. Exactly similarly diseased spots were produced by inoculating young coconut buds with *Phytophora faberi* obtained from the black rot of Cacao pods. The two diseases are therefore considered to be due to one and the same fungus. The same species is also believed by the author on the evidence of infection-results to be the cause of cancer of seedlings of Hevea rubber, of the rot of Papaya fruits. The author points out the importance of this. No measurements or other identification marks are given.

Since it is difficult to imagine the fungus of the Coconut bud rot in the Philipines to be different from that of India, the author's identification is contrary to Butlers. But it must be remembered that the difference between the genus Phytophthora and Pythium is very small—the latter has sexual spores the former has not—and the more we learn about fungi the more we find how polymorphic they may be on different hosts.

P. F. F.

Algae.

Carter, N. Trachelomonas inconstans, a new flagellate. *New Phytologist. Vol. XVIII, Nos. 3 & 4 pp. 118-119.*

In this paper the writer describes a new species of *Trachelomonas* collected from a rainwater pool near longmoor Pool at Sutton Park, Warwickshire. The distinctive feature is the presence of a prominent nodule or spiny excrescence at the posterior end of the organism. The cell is enclosed in a case whose wall is strongly impregnated with iron and has minute pores within its thickness. These pores become quite distinct after staining with hæmatoxylin.

Bristol, B. M., Retention of vitality by Algæ. *New Phytologist. Vol. XVIII, Nos. 3 & 4 pp. 92-107.*

The author records spores of a large number of algae showing retention of vitality for a very long period, sometimes as many as 70 years. Samples of soil were taken which were bottled 45 to 70 years ago and put in sterilized culture-media. After some time a number of algal species made their appearance in the cultures. Thus two algae, namely, *Nostoc muscorum* Kutz. and *Nodularia Harveyana* (Thwaits) Thuret, were found in nearly all the cultures, even in those which contained soil about 70 years old; *Anabæna oscillaroides* Bory. var. *terreseris* n. var, *Cylindrospermum licheniforme* (Bory) Kutz. and *Chlorococcum humicola* (Naeg.) Rabenh. grew again after 59 years' rest; *Trochiscia aspera* (Reinsch) Hansg., *Stichococcus bacillaris* Naeg. and *Nitzschia Palea* (Kutz) W. Sm. after 48 years' rest and *Anabæna laxa* A. Br. (?) after 46 years' rest.

Carter, N. Studies on the Chloroplasts of Desmids II. *Annals of Botany, Vol. XXXIII, pp. 295-304.*

In this paper the chloroplasts of a number of species of *Micresterias* are described. There is normally one chloroplast in each semicell. Each chloroplast consist of a more or less distinct axile plate parallel to the front faces with a number of ridges arising from it, which project towards the cellwall in different directions. In flattened-celled species the ridges are insignificant or even absent, while in thick-walled species they are very large and sometimes branched. In thinner cells there are more pyrenoids than in thicker ones. Each chloroplast is hollowed out in the centre of the cell to accommodate the nucleus.

Carter, Nellie. On the cytology of two species of Characiopsis. *New Phytologist, Vol. XVIII, Nos. 5 & 6 pp, 177-186.*

The author has worked out in detail the cytology of *Characiopsis Naegli* (A. Br.) Lemm. and *Ch. saccata* n.sp. The interesting points about *Ch. Naegli* are the internal hollow invaginations of the cell-wall into the cytoplasm, numerous disc-like chromatophores which fill most of the cell cavity, a very large number of nuclei (sometimes more than sixty), absence of pyrenoids, and the presence of oil as its food reserve.

The species *Ch. saccata* is characterised by its acute apex, no internal invaginations of the cell wall, fewer and thinner chromatophores occupying only the peripheral portion of the cell cavity, fewer nuclei and their peripheral position.

She then describes a species of *Characium, Ch. Angustum* A. Br., for comparison with the two species of *Characiopsis* described above, and points out

the absence of chromatophores and presence of pyrenoids and starch in the former, which characters differentiate the genus *Characium* from *Characiopsis*.

S. L. G.

Biography.

John Goodyear of Mapledurham by G. Claridge Druce, *Suppl.* to the *Botanical Exchange Club Report 1916.*

This booklet which has only just now come into my hands is an account, compiled it is clear with great industry, of John Goodyear, a native of Hampshire, who lived 1593—1664, and was one of Englands early Botanists. He grew in his own garden many interesting plants, including at that time, the very rare Jerusalem artichoke, the tubers of which however he evidently found disappointedly indigestible; but moved later to Oxford, attracted no doubt by the recently opened Garden of Physic. The record of his work lies chiefly in references by Johnson in his second edition of Gerard's *Herbal*, but also by John Parkinson in *Paradisus Terrestris*, William How in *Phytologia Britanica* and Merrett in *Pinax*. Those who know and love their English flora will find interesting details of the first mention of many species as growing in Hampshire or even in England. To others perhaps the chief interest will lie in the striking confirmation afforded of the difficulties the earlier Botanists had in naming their finds, and of the tremendous service rendered by Linnæus in his establishment of a simple and workable system of nomenclature. Some of the names call for no particular remark except as being curiously literal translations into Latin of the common English ones, *e.g. Gramen Parnassi* for the Grass of Parnassus (*Parnasia sp.*). But what chiefly strikes one as illustrating the debt we owe to Linnæus is the length and clumsiness of many of the names, which were used prior to that botanists day. Thus what Linnæus afterwards called, and we now call, *Galeopsis tetrahit*, was *Cannabis spuria altero. flor. purp.* (the purple flowered spurious Hemp). *Potamogeton crispus* L. was known as *Tribulus aquaticus minor quercus floribus* (the lesser waterweed, oak-flowered), and *P. densus* L. as *Tribulus aquaticus minor muscatellae floribus* (the lesser waterweed with flowers of the Muscatell). No doubt "aquatic tribulation," if that is a nearer translation, would fittingly describe this troublesome genus, but what a clumsy way of distinguishing the species, compared with Linnæus' binomial system. The descriptions it may be said were always in English, only the names in Latin. Goodyear's careful descriptions of the four different kinds of Elm (one of which, not the Wych Elm, he called Witch Hasell) are quoted in full as showing the character of his work, and a list is given of his MS. notes and of the very fine collection of books which he presented to the Library of Magdalen College, Oxford.

P. F. F.

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It would greatly assist the Honorary Editor if the following rules are kept in mind by contributors :—

All matter for the printer should be typed and on one side of the paper only. The name of a genus should begin with a capital letter, but that of the species only when it is adapted from a proper name (Vienna Rules). No comma should be put in after the specific name and before that of the founder of the species. The Editor will see to the type but the writer may, if he likes, indicate it on the following lines. The name of a plant at the opening of a paragraph or when it is desired to direct special emphasis to it may be underlined wavy (~~~~~~~~) for printing in **antique** type, with the founder's initial or name underlined plain ————) for *italics ;* thus **Acalypha indica** *L.* If in the middle of a paragraph the name should be underlined plain, but the founder's initial not, thus *Acalypha indica* Linn.

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DISTRIBUTION OF LIVERWORTS IN THE WESTERN HIMALAYAS

BY

S. R. KASHYAP,

Professor of Botany, Government College, Lahore.

A few months ago the writer had an occasion to visit the eastern part of the Chandrabhaga valley, the Lingti plain beyond the Inner Himalayas, and the Beas valley, where collections of Liverworts were made. These collections along with others made in various other parts of the Western Himalayas by the writer during the last few years afford sufficient data for a survey of the general distribution of Liverworts in this region which it is proposed to discuss in this paper. A number of species from various parts of the Western Himalayas has already been published by the writer in the New Phytologist, 1913 and 1914, and the Journal of the Bombay Natural History Society, 1916 and 1917.

GEOGRAPHICAL.

By "Western Himalayas" is to be understood that part of the Himalayan range which extends from the Baralacha pass on the east to the Indus in Gilgit on the west. On the Baralacha pass are the sources of the Chandrabhaga on the southern side while on the northern and eastern sides are the feeders of the Indus and the Sutlej respectively. About this place also the main Himalayan chain gives rise to a branch, the Middle Himalayas, a continuation more or less of the main axis, and running to the west parallel to the above-mentioned range towards its south. The Middle Himalayan range gives rise, near its beginning, to a high ridge, the Bara Bangahal range, running at right angles to it towards the south, which forms the watershed between the Beas on the east and the Ravi on the west. From the Bara

Bangahal range is given off another range towards the west running more or less parallel to the Middle range. This range is known as the Outer Himalayas. The Middle and the Outer ranges may be said to terminate where the Chandrabhaga and the Ravi respectively pierce them to debouch on the plains. Going up one of the feeders of the Chandrabhaga from Kashtwar one has to cross a range which separates the waters of the Chandrabhaga from those of the Jehlum in order to enter the valley of Kashmir.

A few more facts in connection with the geography of these ranges should be borne in mind before discussing the distribution of any group of plants. The Outer Himalayas have a mean altitude of about 15,000 ft., though some peaks rise up to 17,000 ft. Most of the hill-stations for summer for the Punjab are situated on this range at an elevation of about 6—7,000 ft., as Simla, Dalhousie, Murree, etc. The passes in this range are about 8,000 ft. high. The Middle Himalayas have a mean elevation of about 17,000 ft. though some peaks rise to 19,000 ft. The passes range from 13,000 to 17,000 ft. The inner range has a mean altitude of about 18,000 ft. though some peaks rise to more than 20,000 ft. Passes range from 17,000 to 18,000 ft. in Pangi. The lowest pass is the Zojila in Kashmir, 11,000 ft. The Baralacha in British Lahoul is 16,200 ft.

Area Visited.

The places visited by the writer are sufficiently numerous and different as regards altitude, etc., to provide reasonably reliable data for the study of distribution though naturally there is a great field for more work in this direction as the area under investigation is so large and diversified while the interior is not easily accessible and requires a certain amount of equipment to be explored.

In the Outer Himalayas the writer has visited Simla, Dalhousie, Murree and some other smaller places but the collections from some of the latter (including Murree) are not sufficiently large to draw detailed conclusions though notes as regards the relative numbers of individuals of Liverworts are available. The Beas valley (Kulu) has also been visited. The Outer Himalayas have been crossed at two places to enter the Ravi valley and at one place (Murree) to enter the Jehlum valley. The Middle Himalayas have been crossed at two places at quite a long distance from each other, the Sauch pass (14,300 ft.) leading to Pangi and the Rohtang pass (13,400 ft.) between Kulu and British Lahoul. The Ravi valley has been explored along the river from Chamba to Chhatrari. The Chandrabhaga has been followed from its source to about 200 miles. The Kashmir valley was entered from the Chandrabhaga valley by crossing the Sinthan

pass. The Inner Himalayas have been crossed only at one place, the Baralacha pass (16,200 ft.). The country beyond that has been visited for about twenty miles up to Lingti Sumdo but the climatic conditions on that side are so uniform over large areas that nothing new would probably be found even much further inwards. The minimum elevation of this region is 14,000 ft. In all cases the forms collected most were from the road-side along the rivers at different levels and at various levels during the crossing of the ranges though short excursions were also often made away from the main road.

General Results.

The more important general conclusions may be stated briefly as follows :—

Most of the species found in the Western Himalayas are thallose.

In the Outer Himalayas the number of species found at a given altitude decreases in proceeding from the eastern end to the west. This decrease is very much more marked if we take into consideration the number of individuals. (*Vide* lists of species at the end.)

As regards vertical distribution, the number increases up to a certain height in going from the plains. The number in the plains is very small. It increases up to about 7,000 ft. and begins to decrease again after that. This applies also to the number of individuals. (*Vide* lists of species at the end.)

On the northern side of the Outer range the same law holds good but the number of species and individuals is much smaller. Thallose forms are chiefly found only near springs. In other places they are as a rule absent.

The horizontal distribution in the Ravi valley probably follows the rule given above but the data are too few to admit of a definite statement being made. (*Vide* list.)

On the southern side of the Middle Himalayas the number is even smaller than on the northern side of the Outer range, and it decreases as we go up.

In the Chandrabhaga valley it can be definitely stated that the number decreases as we go down the river. The number on both sides of the river is very small, but of the two the left bank, *i.e.*, the northern slope of the Middle range is comparatively richer. Pangi is the only part where any foliose forms have been met with. They are absent both to the east and west of it.

The initial level of this valley is very high, being above 8,000 ft. in the Chamba territory. The largest number of individuals is met with between 8,000 and 9,000 ft. in Pangi and up to 11,000 ft. in British Lahoul. The explanation of this difference no doubt lies

in the fact that the latter part is much more open. The initial level of the valley is of course higher in Lahoul than in Pangi.

There are absolutely no Liverworts beyond the Inner range. Of the other cryptogams only one alga which looked like a spirogyra was seen. No fungus, but two or three lichens were observed. One or two species of mosses were noted near running water. Only a single fern plant was seen but unfortunately was not identified. The flowering plants of this interesting region would be dealth with at a later date. It may perhaps be mentoined by the way that red snow due to the unicellular alga *Chlaydomonas nivalis* was observed just below the Baralacha pass on the south side at about 16,000 ft.

The facts of vertical distribution on the southern slopes of the Outer Himalayas can readily be explained by the increase in the rainfall with the increase in height up to a certain limit after which the very low temperature acts as an adverse factor.

One interesting result as regards vertical distribution is that both the highest and the lowest genera of the Marchantiales are met with at the highest and the lowest levels. The lowest genus *Riccia* is represented by *R. robusta* at Lahore (700 ft.) and at Lahoul (11,000 ft.). Of the highest genus *Marchantia*, *M. nepalensis* and *M. palmata* are very common in the plains and the outer Himalayas up to about 7,000 ft., while *M. polymorpha* goes up to about 11,000 ft. in the Chandrabhaga valley. Another genus, *Grimaldia*, about midway between the lowest and the highest genera is also widely distributed in this region. The only Indian species, *G. indica*, is very common from the foot of the Himalayas to about 11,000 ft.

The horizontal distribution is not so easy to explain. That the rainfall is not an essential factor is shown by the fact that it does not differ very much in the different places where collections have been made. Probably temperature connected with a higher latitude has something to do with it. The problem requires more study.

In the Ravi valley the rainfall is not a very important factor as it is not very high and is accompanied by a comparatively low temperature, and Liverworts are thus generally met with only near permanently moist places. A few occur otherwise.

In the Beas valley (Kulu) although the rainfall is not very high but the broad valley is surrounded by hills on all sides and at higher levels there is a luxuriant Liverwort flora which compares very well as regards the number of species and individuals with localities further to the east.

In the Chandrabhaga valley rainfall does not count as a factor at all in the distribution of Liverworts. It is very small and therefore

has no effect. The only place for which rainfall data are available is Kyelang in British Lahoul. It is about six inches during the whole season (June to September) and including the melted snowfall it is not more than twenty-three inches in the whole year. During the greater part of the year it is very cold.

Beyond the Inner Himalayas the dry and cold atmosphere does not allow any Liverwort to grow. The rainfall is extremely small and the temperature very low. Strong winds are usually blowing. The country is a desolate barren desert.

Floristic Details.

Below are given the lists of species found at the different places visited. Of course some more species are certain to be found at every one of these places when a more intensive study is undertaken and more time is devoted to each place, but it may safely be stated that this number would in no case be very large and since this statement affects all the places equally the relative abundance of the Liverwort flora of any locality is not affected. It may also be stated that all these places were visited some time between the end of June and the end of September though several were visited at other times of the year also. The best time for Liverworts in the Himalayas is between July and September. In the plains the best time is late winter and spring.

[1] Mussoorie. (6-7,000 ft.)

Mean Max. temp.—Mean min. temp.— Long. 30° 27′ N. Lat. 78° 5′ E. Average annual rainfall 96″. (Though this hill-station is not situated in the Western Himalayas strictly speaking, but the list would be useful for purposes of comparison of the West and East Himalayan floras.)

1. *Riccia himalayensis* St. 2. *Targionia hypophylla* L. 3. *Cyathodium tuberosum* Kash. 4. *Aitchisoniella himalayensis* Kash. 5. *Athalamia pinguis* Falc. 6. *Gollaniella pusilla* St. 7. *Plagiochasma appendiculatum* L. et L. 8. *P. articulatum* Kash. 9. *Reboulia hemispherica* (L.) Raddi. 10. *Fimbriaria Blumeana* Nees. 11. *F. angusta* St. 12. *F. mussuriensis* Kash. 13. *Grimaldia indica* St. 14. *Stephensoniella brevipedunculata* Kash. 15. *Exormotheca tuberifera* Kash. 16. *Cryptomitrium himalayense* Kash. 17. *Dumortiera velutina* Schffn. 18. *D. hirsuta* (Sw.) R. Bl. nees. (?) 19. *Marchantia nepalensis* L. et L. 20. *M. palmata* Nees. 21. *Ancura indica* St. 22. *Metzgeria pubescens* (Schrank) Raddi. 23. *Metzgeria himalayensis* Kash. (Both species at about 5,000 ft.) 24. *Pellia calycina* (Tayl.) Nees. 25. *Fossombronia himalayensis* Kash.

[1] Where climatological data are not available the spaces are left blank.

26. *Sewardiella tuberifera* Kash. 27. *Anthoceros himalayensis* Kash. 28. *Anthoceros erectus* Kash. 29. *Notothylas Levieri* Schffr. 30. *Madotheca macroloba* St. 31. *M. Gollani* St. 32. *M. appendiculata* St. 33. *M. sp.* 34. *Lopholea minor* Nees. 35. *Chiloscyphus himalayensis* St. 36. *Frullania himalayensis* St. 37. *F. retusa* Mitt. 38. *Plagiochila sp.* 39. *Solenostema purpurata* Mitt.? 40-42. *Lejeuneas.*

In this locality Liverworts occur in great abundance. Cliffs are covered with huge patches of thallose forms and in suitable places trunks of trees and rocks have dense masses of foliose forms on them.

Kulu, Dulchi pass. (6,000-7,000 ft.).

Long. 31° 50′ N. to 32° 26′ N. Lat. 76° 56′ E. to 77° 33′ E. Aver. annual rainfall, 47.9 in. Mean Max. temp.—Mean Min. temp. (Long. and Lat. are of Kulu Tahsil, the other data apply to Nagar.)

The following species were collected. The references are to the list given under Mussoorie :—

Nos. 1 to 16, 19, 24, 25, 27, and in addition *Plagiochasma simlensis* Kash. and 2 or 3 foliose forms. More would certainly be found if a careful search is made for them. Practically all of these were collected along the road-side within a space of a few yards. *Riccia pathankotensis* Kash. and *Fegatella conica* were collected at a lower level in the same valley. Many of the above species occurs at other levels also in Kulu.

In numbers the flora is almost as abundant as Mussoorie.

(Simla. 6,000-7,000 ft.)

Long. 31° 6′ Lat. 77° 10′ E. Aver. annual rainfall. 63 in Mean Max. temp. 61.9° Mean Min. temp. 51.3°

Nos. 1 to 11, 13 to 17, 19 to 21, 24 to 29, and in addition *Riccia pathankotensis, Plagiochasma simlensis* and *Fegatella conica.*

The number of individuals is quite large, nearly as abundant as at Mussoorie.

Dalhousie. 6,000—7,000 ft. (7,687 ft.)

Long. 33° 32′ N. Lat. 75° 58′ E. Aver. annual rain. 86.35″. Mean Max. temp.—Mean Min. temp.

Nos. 3, 7 to 9, 13, 21, 24, *Lophocolea* (2 species), *Chiloscyphus sp., Frullania retusa.* Some more species would no doubt be found but the flora is undoubtedly very poor both in numbers of species and individuals, very much poorer than in the first three localities.

Murree. 6,000—7,000 ft. (7,517 ft.)

Long. 33° 55′ N. Lat. 73° 23′E. Aver. annual rain. 59″. Mean Max. temp. 65.9°. Mean Min. temp. 52.9°.

Full list not available, but flora certainly poor. Very much like Dalhousie, perhaps poorer.

Of the next two localities the first, Pathankote, is at the foot of the Outer Himalayas, and the second, Lahore, is in the plains. The poverty of the species is noteworthy,

Pathankote.

Long. 32° 16 N. Lat. 75° 40′ E. Aver. annual rain. 47″ Mean. Max. temp.—Mean Min temp.—*Riccia pathankotensis*, *Grimaldia indica* and *Fimbriaria pathankotensis* are the only common species, the first two much more so than the third. The first is quite abundant along the river flowing near by.

Lahore. (700 ft.)

Long. 31° 35′ N. Lat. 74° 20′ E. Aver. annual rain. 19.58″. Mean Max. temp. 90.9°. Mean Min. temp. 64.2.

The only Liverworts that are found throughout the year here and there in favourable places are *Riccia sanguinea* Kash., *Marchantia nepalensis* and *M. palmata*. In winter *Riccia robusta* Kash., *R. cruciata* Kash. and *R. pathankotensis* are also seen, the first in pretty large numbers. *Riella indica* St. appears in some years in a water-channel about March. Very rarely *Plagiochasma appendiculatum*, *P. articulatum*, *Grimaldia indica* and *Anthoceros himalayensis* are met with along the river bank. This list is the result of very thorough observations extending over a number of years and can hardly be improved. All the species except the first three and perhaps the fourth also are undoubtedly brought down from other places by the canal water.

The Ravi valley. (about 3,000 ft.)

The following species have been found. The localities, where recorded, are also noted :—

(Chamba, the main town, is situated at an elevation of 3,027 ft. Long. 32° 29′ N. Lat. 76° 11′ E. Aver. annual rain. 47.60″. Mean Max. temp. 77.7°. Mean Min. temp. 56.5°.)

Targionia hypophylla.
Athalamia pinguis.
Grimaldia indica.
Plagiochasma appendiculatum.
P. articulatum.
Reboulia hemispherica.
Sauchia spongiosa. Chamba-Pangi road, about 10,000 ft.
Fegatella conica. Common in moist places on northern slopes; also Chamba-Pangi road.
Wiesnerella denudata. Above Khajiar.
Dumortiera velutina. Common in moist places.

Marchantia nepalensis.
M. palmata.
Aneura Levieri. Chamba-Chuari road.
Pellia calycina. Common in moist places.
Metzgeria pubescens. Chamba-Pangi road. about 10,000 ft.
Calycularia crispatula. Dalhousie-Khajiar road.
Fossombronia himalayensis. Chamba-Pangi road.
Anthoceros sp. Along the Ravi above Chamba.
Madotheca sp. Pangi road.
Radula sp. Dalhousie-Khajiar road ; Chamba-Pangi road.
Calypogeia sp.
Chiloscyphus gollani St. Pangi road.
C. argutus, Nees.
Nardia sp. Pangi road.
Plagiochila sp.
Arachniopsis sp. Pangie road, about 11,000 ft.
Lejeunia sp. Pangi road.
Frullania sp.

The number of individuals is very small and specimens are found only at long intervals. *Pellia, Dumortiera,* and *Fegatella* are pretty common in or near running water. *Wiesnerella* has been found in one or two places.

Chandrabhaga valley. (8,000—13,000 ft.)

Riccia himalayensis. Near Salgraon, Chamba-Lahoul.
R. sp. Along with the above.
R. robusta. Above Kyelang, about 11,000 ft. Very curious distribution as it occurs in Lahore also at 700 ft.
Grimaldia indica. Above Kyelang, about 11,000 ft. Also occurs at Lahore, etc.
Athalamia dioica. Near Saor, Pangi.
Mindal Pangiensis. Along with the above.
Reboulia hemispherica. Above Kyelang, about 11,000 ft. Very common in the Himalayas.
Fegatella conica. Near Kilar bridge, Pangi, and elsewhere.
Preissia commutata. Along with the above, and elsewhere.
Dumortiera velutina. At the above place and common elsewhere, also in moist places.
Marchantia polymorpha. Common in moist places.
Pellia calycina. Common in moist places.
Pellia epiphylla ? Near Shaichu, Pangi.
Aneura Levieri. Near Shaichu, Pangi.
Anthoceros sp. Near Sissoo, British Lahoul, about 10,000 ft.

Madotheca ovalis Gottsch. Near Kilar bridge, Pangi.
M. sp. Along with the above.
Radula sp. Along with the above.
Arachniopsis sp. Below Gurdhar pass, about 13,000 ft.
Lophozia sp. Along with the above.

The number of individuals is very small and specimens are met with only at long intervals. Going down the Chandrabhaga to Padar and Kashtwar the Liverwort flora becomes decidedly poorer and hardly any specimens are seen for miles. Going up the Chenab no Liverworts are met with above Jispa, about 11,000 ft.

As stated before no Liverworts occur beyond the Baralacha pass in the country visited. It is probable that none occur in the whole of Ladak.

No. of species in the different localities—

Mussoorie	Kulu	Simla	Dalhousie	Ravi Valley	Chenab Valley	Lingti Plain
42	24	28	11	28	20	0
Southern slopes of the Outer Himalayas.				Between Outer and Middle Himalayas	Between Middle and Inner Himalayas.	Beyond Inner Himalayas.

References to Literature

For many geographical and climatic data the writer is indebted to the Gazetteers of Chamba, Kulu and Mandi, and the Gazetteer of India. Some of the figures about temperature and rainfall were obtained from the Meteorological Observatory, Lahore. The area of which the writer has first-hand knowledge has been indicated in the paper. All the species mentioned have been collected by the writer himself. Descriptions of these will be found in Stephani's *Species hepaticarum* and the following papers by the writer :—

1. Morphological and biological notes on new and little-known west Himalayan Liverworts I, II and III. New Phytologist, 1913 and 1914.

2. Liverworts of the Western Himalayas and the Punjab. I and II. Journal of the Bombay Natural History Society, 1916 and 1917.

CONTRIBUTION TO THE STUDY OF THE INDIAN ASPERGILLI

By

Captain Froilano De Mello,

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Aspergillus (Sterigmatocystis) polychromus *Sp. Nov.*

Introduction. It is a very common fact that in India, specially in the rainy season, the culture media in laboratories are covered by a large number of moulds belonging to the most varying genera. In bacteriological investigations, these growths do not matter much, but the difficulties arise when one is dealing with cultures made for the study of human or animal mycoses, a field of research which in India has not yet been fully explored.

The subject of my investigations is the genus "Aspergillus" and its ally "Sterigmatocystis". A systematic study of Indian Aspergilli has not yet been made and it is hoped that this short contribution may not be without value towards this mycologic investigation.

The species I am now describing is quite a new species and it can be easily recognized both by its macroscopic and microscopic characters. In Nova Goa I have, up to the present, identified the following species :—

A. (*St.*) *niger* Cramer 1859.

A. (sensu stricto) *herbariorum* Wiggers 1780.

A. (*St.*) *sulphureus* Fresenius 1863.

A. (sensu stricto) *orizoae* Ahlburg 1876.

Four other species, one white, two yellow and one green, are now under investigation and I will be very thankful if scientists working in India will be kind enough to send me cultures of *Aspergilli* found in different parts of India.

This study would remain incomplete but for the excellent monograph on *Aspergilli* by Whemer. This work was, very kindly, placed at my disposal by Dr. E. J. Butler, Imperial Mycologist, to whom my best thanks are due.

Origin of the Culture. This species was found in August, 1919, contaminating two Erlenmeyer flasks containing Endo's medium and plain agar. One of the cultures was grey, slightly brownish, the other had a light chocolate colour. On cultivating the fungus from these two sources, I was able to identify both these cultures as

belonging to a same species. The colour of the fungus changes, but variations are always uniform according to the age of the culture.

General Colour of the Culture. The colour of this fungus is white *platré* during the first 24 hours; on the second day a slight greyish tone is noticed, on the fourth the culture assumes a light marine blue, on the sixth it becomes greyish blue, on the 8th the greyish tone is predominant and the culture presents a beautiful *gris souris* colour. From the first to the second week the colour changes into a deep brownish, passing through a slightly violet tone. Later on the culture is of a deep chocolate colour, which two months later becomes very clear.

Morphology and Mycological appearance—The morphology of the fungus is the same as noted in the general description of the fungi belonging to these genera. The following elements call forth our attention:—

Conidiophores—length maxim. 650 micr., minim. 112; average taken on 35 conidiophores 275 micr.; breadth 3 to 6 micr.; wall thickness 0, 5 to 1 micr.

Columellae almost always ovoid and claviform, very seldom spherical. When old, they show a brownish pigmentation, more concentrated in the superior pole. Diameter of the spherical type 8 to 15 micr. Ovoid: length maxim. 25 minim. 10, average taken on 41 columellae, 13 micr.; breadth maxim. 20, minim. 4, average taken on the same number 10, 5 micr.

Sterigmata very densely inserted, generally on the anterior $\frac{3}{4}$ of the columella, rarely radiated. In old cultures a deep brownish pigmentation is noticed. *Primary Sterigmata* ovoid or claviform, 5 to 10 micr. long, 3 to 4 micr. broad. *Secondary Sterigmata* ovoid or lanceolated 5 to 8 micr., long, 3 to 4 micr. broad.

Conidia round, finely punctuated, bluish green at first, light brown at a latter stage, finally chocolate colour; 2, 5 to 5 micr.

Heads (Columella+Sterigmata+Conidia) round and elliptical. Diameter of the round forms; maxim. 55, minim. 36, average 42 micr. Dimensions of the elliptical forms: length maxim. 80, minim 10, average taken on 20 heads 45 micr.

Perithecium yellow with a greenish tone, found only in old cultures aged at least two months; 30 to 35 micr. of diameter.

Cultural characters. Plain agar. Good development, the cultures having the following coloration: 48 hours, white *platré*; 3 days, greyish; 5 days, slight bluish tone; 9 days, *gris souris*; 2 weeks, chocolate brown; 3 weeks, deep chocolate; 2 months, clear chocolate; 3 months, idem.

Glucosed sabouraud—Idem, very good development, the colours being more vivid.

Maltosed sabouraud—Very weak development; colours idem.

Endo's medium—Idem as on glucosed sabouraud.

Lemon—48 hours, weak development, clear blue; 3 days, greyish blue; 1 week, deep blue with a greyish tone; 2 to 3 weeks, idem.

Bread paste—48 hours, weak development, blue greyish green; 1 week, idem; 4 days, clear green; 2 to 3 weeks, dirty green.

Banana—3 days blue *outremer*, good development, 5 days, idem; 2 to 3 weeks idem with a greenish tone.

Rice; *paste*—1 week, poor development, of white slightly green colour; 2 to 3 weeks, good development of the same colour.

Carrot—3 days, good development, yellowish green; 5 days, idem; 2 to 3 weeks, green with yellowish tone.

Potato—3 days, good development, white slightly green; 1 week, green straw colour; 2 to 3 weeks, dark green.

Glycerinated potato—10 days, poor development, white colonies; 2 weeks, idem; 3 weeks slightly blue greyish; 1 month, deep grey.

Coagulated milk—The culture is blue slightly greenish, the greenish tone becoming predominant after 2 to 3 weeks.

Pineapple juice—48 hours, clear blue, isolated colonies fluctuating on the surface of the liquid; 3 days, idem, the colour being the same but with a slight greyish tone; 5 days, the colonies become confluent and form a very consistent membrane; 1 week, the same colour, the bluish tone becoming more pronounced; 10 days, greyish blue, 2 to 3 weeks, greyish to gris souris and the bluish tone changing into the greenish.

Mango juice—The colour of the culture is the same as in the pineapple juice, but the culture shows the form of a ring, strongly adhering to the wall of the tube.

Bouillon—48 hours, minute isolated colonies of white bluish colour, becoming greyish blue after 1 week and finally dark grey.

Glucosed bouillon—Idem, the colonies being more abundant and confluent and forming a membrane on the surface of the liquid.

Maltosed bouillon—48 hours, greyish blue membrane; 4 days, idem, the vegetative mycelium (inferior face) having the appearance of a gelatinous mass and a brownish yellow colour; 4 days, the grey tone becomes more pronounced; 3 weeks, dark grey with greenish tone.

Straw bouillon—idem without the final greenish tone.

Bouillon of vegetables—Idem, the mass of the vegetative mycelium has the same gelatinous appearance as in the *maltosed bouillon*.

Inoculations—One rabbit and one guinea-pig inoculated by intravenous injection remained healthy till the end of the experiment.

On account of the variations of the colour in the cultures of this

fungus, I have named this species *Aspergillus* (*Sterigmatocystis*) *polychromus* My best thanks are due to my Assistant Dr. J. A. de Carmo Vaz, for valuable collaboration given to me in the course of this study.

Aspergilius (Sterigmatocystis) polichromus, species nova, fungus saprophiticus, ostendens, cultionis subjectus, coloris variationes secundum cultionis actatem uniformes, sclicet: albo-niveum colorem in nitio (24 horis), suaviter cinereum (2a. die), suaviter ceruleo (4a. die) et deinceps succesive cinereum, violaceum, ravum (post 2 hebdom.) aquiloalbum.

Elementa morphologica notabilia:—*Conidiophora* 601 (micr longa maxime, 112 minime, 275 medie:—*Columellæ* generatim ovoides vel claviformes, ostendentes pigmentum aquilum superiori polo, in vetustate, 10 ad 25μ longae, 4 ad 20 latae, cum sterigmatibus *primariis*, sc. ovoid. vel lanceolat. 5 ad 10μ longis et 3 ad 4 latis; et *secundariis* sc. ovoid. vel lanceolat. 5 ad 8μ langis et 3 ad 4 latis; *Conidiæ* rotundae 2, 5 ad 5μ in ambitu;—*Perithecia* in cultionibus tantu veteris a 2 saltem mensibus inveniuntur, 30 ad 35μ longa, aliquantulum minus lata, cum *ascis* rotundis et in unoquoqu 4 ascosporis.

MILIUSA AND SACCOPETALUM.

(Family Anonaceæ)

By

J. R. Drummond, F.L.S.

The genus **Miliusa** was founded by Alphonse De Candolle (in Mem. de la Soc. de Phys. et d'Hist. nat. de Geneve vol. V., 1832) on a plant collected by Leschenault de la Tour " in montibus Cotta-lam dictis ad peninsulæ indicæ meridiem ". Cotta-lam has been indentified with Courtallam in the Tinnevelly District of the Madras Presidency (S. India).

The generic character, rendered into English, is as follows :—

Corolla gamopetalous, campanulate, three-lobed. Stamens 12? with slender elongate filaments, and very small anthers. Receptacle ovoid. Ovaries indefinite, 2-ovuled, the ovules superposed. Carpels free.

From the detailed description we gather further that the *Miliusa* was a low shrub with bifarious elliptic leaves, and solitary axillary flowers, consisting of a trifid gamopetalous corolla (or three petals, about nine lines long, connate for half their length) concave or hooded at the base concealing the pedicel and the small calyx of three sepals, the petals folded internally so as to form three hairy fimbriate appendages, one opposite each of the main lobes of the corolla. The anthers, scarcely 1/20 line long, are inserted on the receptacle, supported by slender glabrous filaments, and rounded. The receptacle is very hairy. De Candolle observes " Genus ex habitu, corolla gamopetala, basi concava, et interne reduplicata, distinctissimum."

Plate No. iii accompanying the Memoir represents "*Miliusa Leschenaultii*, Alph. DC." which is manifestly the *Miliusa indica* of the text, although at the right hand upper corner a portion of a leaf (figure 8) is included which is not accounted for in the letter press, and may belong to some other plant.

From this illustration it appears that the torus in *Miliusa indica* consists of two portions, of which the lower, constituting about one-fifth of the whole, is glabrous, the remaining four-fifths being pilose; the stamens are inserted at the division between these two portions and the corolla, at the base of the lower (glabrous) fifth; one corolline whorl is visible, the lobes of which are connate for about two-thirds of their length, and prolonged, " hooded "—or rather saccate—, at their bases, completely hiding the small sharply refracted "calyx", of which the segments are rather strongly ciliate;

the appendages of the corolla appear as tufts of hairs inserted at the base of the torus, remaining after the petals have been taken away. It should be here noted that the whorl which the author described as a calyx may have been in fact an outer series of petals, conforming, as in certain allied species, to the true sepals, which in this case, however, must have been highly caducous.

In 1834 Wight and Arnott (Prodromus p. 10) under "*Miliusa indica* (Lesch.)" reproduced A. Le Candolle's leading characters, but assigned them to "Wall. L.n. 5433," quoting as a synonym "Uvaria ciliata, Heyne MSS." There is a specimen at Kew ticketed *Uvaria ciliata*, Heyne Tenmalej near Courtallam, July 1815," and on the same sheet is a second ticket from which it seems probable that the citation of "Wall. L.n. 5433" may refer to this specimen or to a duplicate.

In April 1835, Wight got a plant at Courtallam which he ultimately referred to *Miliusa indica*, and in the following July and August he collected further specimens which together with the April gathering have since (1866-67) been distributed from Kew as No. 34 of the Indian Peninsular Collections. These later gatherings (in part) resemble "*Uvaria ciliata*, Heyne" so far as can be judged, but Heyne's specimen is not in fruit: No. 34 of Wight has drupes and matches an example from his own Herbarium, without date or original locality, with which is now attached a description in his own handwriting. This description, however, seems to have belonged to the specimen distributed under No. 33 as "*Miliusa montana*, Gardner" (which in Fl. Brit. Ind. i. 86 is reduced to M. indica) and to have been pinned to the sheet where it is now found by accident. A pencil note on the sheet from Wight's own Herbarium (in Sir J. D. Hooker's handwriting apparently) points out that the plant there represented differs from No. 33 by the ripe carpels being sessile and pubescent-tomentose. This form (No. 34 in part) seems to have received from Wight the manuscript name of "*M. affinis*". Nothing on these sheets can be referred to Alph. De Candolle's *M. indica* unless we assume—

(1) that the sepals, which in Nos. 33 and 34 Herb. Pen. Ind. are manifest, may sometimes fall off at a very early stage, or

(2) that the sexes are diclinous and that the structure of the androecium differs in the male and female flowers very widely, or

(3) that the arrangements of the floral whorls is remarkably unstable.

How far any parallel to the degree of instability that must be supposed in this case has been observed in other Anonaceæ is a question which may be deferred for the present. In the "Illustrations" i. p. 68 (1840), Wight met this difficulty by suggesting that De

Candolle was misled by imperfect material, and this theory was adopted and elaborated in the same year by J. J. Bennett, when dealing with a tree found by Horsfield in the "Banyumar Province" of Java, on which Bennett's genus *Saccopetalum* was founded (Plaht. Jav. Rar. p. 165 t., xxxv : 1840).

Bennett remarked that since the publication of the family in De Candolle's Prodromus two new genera of Anonaceæ had been constituted, viz., *Miliusa* and *Hyalostema*. With "Hyalostemma we need not concern ourselves further than to say that it was coined by Wallich without any diagnosis, for a plant which had been duly described by Roxburgh (Fl. Ind. ii. 660) as *Uvaria dioeca*. Bennett's note adds nothing to the history of "Hyalostemma" (which has subsequently been dropped by common consent), and his discussion of De Candolle's plant does not advance the history of *Miliusa*, because he postulates the identity of Wight's species with "*Miliusa Leschenaultii*", which, as we have seen, can only be accepted by making alternative assumptions, in support of which no proof has been put forward.

As it happens, a good deal of the reasoning expended on the matter is invalidated by facts since discovered. Speaking of that group of Anonaceæ, of which *Miliusa* has been taken as the type, Bennett writes :—

"The stamina also are subject to some modifications, less extensive however than the character and description of *Miliusa* given by M. Alph. De Candolle would lead us to believe. Their number in that genus, according to my observation, is about 27 instead of 12, forming three alternating series, in each of which two are opposed to each of the inner, and one to each of the outer petals". Now, in *Miliusa nilagirica* Beddome, Ic. Pl. Ind. Or. t. lxxxviii (1876) there are but eight stamens : that this is a *Miliusa* no one probably will dispute, and in that case Bennett's estimate of the stamens as "about 27" obviously calls for revision. It seems even possible that this plant, and not either of Wight's Miliusæ, was the true *M. Leschenaultii*. The glabrate middle surface and margin thickened towards the apex of the petals, which are given as distinctive of *M. nilagirica* are approached in some examples of *M. montana*, Gardner, and these differences are not sufficient, perhaps, to mark off Beddome's species from that of De Candolle. Beddome's illustration lxxxv serves to contrast *M. affinis*, Wight MSS.,—which is there figured as "*M. indica*",—from *M. Leschenaultii*. The number of the stamens in the last differs, as observed, from that *M. nilagirica*, but it may be questioned whether the number is so fixed in this group as was supposed by Bennett. As regards the structure of the valvate petals he has very justly noted that the gamopetaly of the inner row is less

real than apparent, being due to a partial cohesion of their edges, which in certain other Anonaceæ takes place, so to speak, in an inverted order, the cohesion being at the tipes, so as to form a canopy over the androgynœcium, somewhat as in *Vitis*.

More disputable matter is involved in his next argument, as follows :—

"Now the three supposed divisions of the calyx in M. De Candolle's figure alternate with the three cohering divisions of the corolla and consequently represent the outer petals, the calyx being thus altogether omitted. In the description this deficiency seems to be supplied by the three supposed internal appendages opposite the base of the cohering petals, of which, however no traces are observable in the figure", and he adds, "This supposition" (i.e. that the outer row of petals was taken for a calyx) "may at least serve to explain the description; it is less easy to account for the figure, but it may be presumed that the artist, aware that the plant was described as having only three division to its calyx, was satisfied with "having found that number of sepaline parts, and it is possible that the true sepals (easily detached at maturity as in *Saccopetalum* and *Hyalostemma*) may have fallen off during the process of manipulation".

It is obviously just as likely that the "sepals" were naturally caduous; but the case of the fimbriate processes rests on a distinct footing, because, although somewhat disguised in the drawing by a dotted line (b), which indicates the point of insertion of the corolla, they are quite clearly shewn in the figure. These organs are perhaps correlated with the special structure of the androgynoecium, and the saccate, probably nectariferous, development of the "petals". Traces of like tufts seem to the writer to be present in other species of *Miliusa* as well, and it may be that the degree of their development is variable even in the same species, as is seen to be the case with the so-called petal-claw or gland in certain species of *Grewia* from the same parts of S. India.

Further material and particularly observations in the field may necessitate emendation, but in the meantime local botanists will presumably keep up *Miliusa Leschenaultii* (type of the genus), *M. affinis*, *M. Montana*, and *M. nilagirica* as distinct, though closely allied species. If facts should be adduced in the future to shew that *M. Leschenaultii* and *M. nilagirica*, or *M. affinis* and *M. montana* should be looked upon as a single unit, it is comparatively easy to carry out the necessary technical corrections.

To return to the history of the genus,—Bennett, having as he believed disposed of *Miliusa Leschenaultii*, went on to establish his

new genus *Saccopetalum*: but as is shewn in the Genera Plantarum (Vol. I, p. 28), the only distinction between *Saccopetalum* and *Miliusa* lies in the saccate petals of the former, whereas A. De Candolle in his description no less plainly than in the accompanying figure has given this very character as belonging to the only species of *Miliusa* known up to the time when Bennett wrote, because what is now *Miliusa Roxburghiana*, Hook. fil. & Thom. was excluded and referred to the factitious Hyalostemma. In the Flora Indica, Vol. I, p. 92, the generic character was amended by restricting *Miliusa* to those species that have not more than two ovules, but as further species were examined this distinction seems to have been found untenable, though retained in a modified form in the Flora of British India, due warning being at the same time conveyed that *Saccopetalum* had been reduced to *Miliusa* by Baillon (Hist. des Plantes I 244).

Hook. fil. & Thom. at the same time pointed out that *Saccopetalum tomentosum* is intermediate between *Saccopetalum* and *Miliusa*, i.e. presumably between *Miliusa affinis* of Wight MSS. and the Javan *Saccopetalum Horsfieldii* of Bennett. Baillon (l.c.) and Prantl. (Nat. Pflanzenfam. III 2.29) do not even admit *Saccopetalum* to the rank of a subgenus. Comparing the number of the ovules in the different genera included in the "Genera Plantarum" under Miliuseæ we hardly find sufficient ground for maintaining *Saccopetalum* as an independent genus; in *Orophea*, it is true, it is said that there are never more than four ovules, and in *Alphonsea* always more than four, with eight as a maximum; but in Bocagea, which is admittedly closely allied to *Miliusa*, they are given as 1—8. In the critical note now attached to a sheet from his own Herbarium, written up at Kew (by Sir J. D. Hooker probably) as '*Miliusa affinis*, R. W.', mentioned above—Wight has observed "On examining the ovaries of *Miliusa* somewhat advanced, I find them containing 2-3 and, once or twice, 4 ovules superposed; also probably there are two or three species distinguished by the stamens being few or numerous and the carpels glabrous or hairy". Whether therefore we assume that the number of maturing ovules differs in the species, or that it varies with the individual, little weight can be attached to this character in discriminating *Miliusa* from its allies. It appears, moreover, that in *Saccopetalum* the number or the ovules is not always six or more; in the 'Flore Forestière de la Cochinchine' at plate 38 (1881) Pierre has figured and described as *Miliusa Bailloni* a tree so closely allied to *Saccopetalum Horsfieldii*, that the two could not properly be referred to different genera, but in this plant it is expressly noted that the ovules are not more than four in number.

In attempting to frame an amended definition of the genus *Miliusa*

two special difficulties are encountered; the one is due to the obscurities, above stated, which surround De Candolle's type; the other is presented by the genus *Phœanthus* of Hook. fil. and Thomson (Flora Indica p. 146). Phœanthus cannot be discriminated from *Miliusa*, whether *Saccopetalum* be merged in *Miliusa*, or accepted, save by the structure of the staminary whorl; but Baillon (*Adansonia viii 1868, pp. 312 et seq.*)— has given reasons for thinking that this character does not in fact possess the value formerly assigned to it, and *Phœanthus* is so nearly akin to the type of *Saccopetalum* in habit, in the structure of the outer floral whorls, and of the ovary, that this genus also should perhaps be reduced to *Miliusa*.

The arrangement of the highly natural but difficult family of the Anonaceae might possibly be simplified, if, instead of attempting to distinguish between 'sepals', and 'petals', the floral envelope were treated, for taxonomic purposes, as a single perianth, consisting of subsidiary, sometimes sharply differentiated, whorls.

In the subjoined description, for the sake of convenience, the accepted characterization of the perianth whorls has been followed; the species placed under *Phœanthus* of Hooker and Thomson have, for the same reason, been excluded.

MILIUSA

Genus Anonacearum imprimis ex-indicatione Leschenaultu ab Alph, Candolles in Mem. Soc. Phys. et Hist. Nat. Genev. vol. V (1832) p. 37, t. iii supra speciem unicam Indicam constitutum, nunc propter plures species nuper recognitas iterum ut sequitur breviter descriptum.

Flores hermaphroditi vel unisexuales, in cymis, vel fasciculis dispositi, aut in axillis solitarii. *Sepala* tria, inconspicua, basi vix connata. *Petala*, aestivatione valvata, per duo verticillos valde dissimiles disposita, exteriora parva sepaloidea, nonnunquam refracta, interiora majora, vix androecium celantia, membranacea vel hyalina, nec unguiculata, nec ad apicem producta, versus basin concava vel saccata, rarius explanata, marginibus plus minus cohærentibus, rarissime discretis.

Torus productus subglobosus vel cylindricus, spice aliquando truncato. *Stamina* 8–12, aut ad 36 in gradibus disposita, ver indefinita antheræ subdidymæ, loculis contiguis ovatis vel rotundatis, extrorsæ, saepius minutæ; filamenta manifesta, attenuata, vel connectivo incrassato, plus minus apiculato, vix superne dilitato. *Carpella* numero indefinita stipitata, matura forma oblonga, ellipsoidea, vel globosa, parum succulenta, indehiscentia, in pseudocarpum nunquam coalita:—ovula in venterali sutura (an semper?) affixa, saepissims bina (rarius unico per abortum superstite), vel indefinita:—

stylus abbreviatus, stigmate simplice oblongo. *Semina* 1-6 (vel plura ?), lateraliter compressa vel in sectione transversa cuneiformia.

Arbores, arbuscula, vel frutices humiliores, per regiones Asiae australes, et Indo-Sinenses, usque ad Australiam subtropicam dispersae. Species circa 21.

It is usual to ascribe the foundation of Miliusa to the discoverer of the type species, but it does not appear that he laid claim to anything beyond the dedication, and the descriptions throughout are evidently the work of De Candolle. The present description is necessarily tentative and is put forward partly as a contribution towards a much needed revision of the family, or at least of that group to which Miliusa naturally belongs. Much better material, in the fruiting stages particularly, must have accumulated since the account in Genera Plantarum was published.

The writer will be grateful for any specimens of Miliusa, Saccopetalum, or Phœanthus that can be spared on loan or otherwise for study at Kew in order to complete a key to the species which it is proposed to include under Miliusa.

CONTRIBUTIONS TOWARDS A FLORA OF BALUCHISTAN.

From materials supplied by Col. J. E. B. Hotson, I.A.R.O.

BY

E. Blatter, S.J., Prof. F. Hallberg and C. McCann.

St. Xavier's Coll., Bombay.

(*Continued from last issue*)

Ficoideae—*Contd.*

Mollugo *L.*

Mollugo nudicaulis *Lam. Dict IV, 234.* Loc.: Rodkan (W Kolwa), about 85 miles E. of Turbar, about 1,800 ft. (no. M 225A); Manguli, 26° 45′ N, 65° 21′ E, about 2,600 ft. (no. M 225C); Awaran, Kolwa, 26° 24′ N, 65° 12′ E, about 1,750 ft. (no. M 225 C bis). Fl. and fr. in April, 1918.

Vern. Name : Askkah (Bal.).

Umbelliferae.

Pycnocycla *Lindl.*

Pycnocycla aucheriana *Boiss. in Ann. Sc. Nat. (1844) 88.* Loc.: 5 miles N. of Mand, about 1,000 ft. (no. M 73); near Kulban (W. Kolwa), about 85 miles E by N of Turbat, about 2,400 ft. (no. M 73 A); Panjgur, about 3,100 ft. (no. M 170, M 73 B, M 73 C.) Fl. in May 1918.

Uses : When people are thirsty they chew the leaves of this small bush. It is said to be very cooling.

Vern. Names : Bibi Butag (Bal.) Kemar (Mandi Bal.), also called Sagi dontan in Panjgur, which is strictly a quite different plant.

Pycnocycla caespitosa *Boiss. and Hauskn. in Boiss. Fl. Or. II, 953.* Loc.: Harboi, 18 miles ESE of Kalat, 9,000 ft. (no. 33). Fl. and Fr. in August 1917.

Uses : Eaten by sheep, etc.

Vern. Name : Humukh (Br.).

Pycnocycla sp. Loc : Below: Harboi, 15 miles ESE of Kalat, 8,300 ft. (no. 81).

Pimpinella *L.*

Pimpinella Stocksii *Boiss. Fl. Or. II, 865.* Loc. : Kalat, 7,000 ft. (no. 4); Garmkan, 12 miles NE of Panjgur (no. M 142 C). Fl. in August 1917.

Uses : The grain is crushed, mixed with water, hot or cold, and swallowed as a remedy against pain in the stomach.

Vern. Names : Harpir (Bal.), Isbot (Br.)

Ammi *L.*

Ammimaius *L. Gen. 334.* Loc. : Panjgur, about 3,100 ft. (no. M, 142, M 142 A, M 142 B). Fl. in March 1918.—Fr. in May 1918.

Vern. Name : Jangli Saleri (Sin.), Harpir (Bal.)

DUCROSIA *Boiss.*

Ducrosia anethifolia *Boiss. Fl. Or. II, 1036.* Loc.: Siahen Damb, about 36 miles E by S of Panjgur, about 3,800 ft. (no. M 176 C); S. end of Gar Pass, about 28 miles E by S of Panjgur, about 3,800 ft. (no. M 176 D); Benn Chah, 21 miles N of Surab, about 6,200 ft. (no. M 383). Fl. in April 1918.—Fr. in April and July 1918.

PSAMMOGETON *Edgew.*

Psammogeton biternatum *Edgew. in Trans. Linn. Soc. XX, 57,* Loc.:: Turbat 63° 4′ E, 25° 58′ N, about 600 ft. (no. M 52); Nagak (W. Kolwa), about 87 miles E by N of Turbat, about 2,400 ft. (no. 50 B.) Panjgur, about 3,100′ (M. 52 A.) Fl. in Feb. 1918.

Vern. Names : Isbot, Isbotk, Isbok (Bal. Br.).

Rubiaceae.

GAILLONIA *A. Rich.*

Gaillonia Aucheri *Jaub. & Sp. Illustr. I, 140.*—Loc.: Nasirabad, 23 miles W. of Turbat, about 400 ft. (no. M 59); Mazhdalu, 20 miles S. of Panchgur, about 3,000 ft. (no. M 59 B); Tumb, 46 miles W. of Turbat, about 600 ft. (M 594)—Fl. and fr. in March 1918.

Uses: The plant is soaked in water and the liquid used to wash babies with pains in their stomachs.

Vern. Names: Tuso (Bal.), Khartusa (Br.).

Gaillonia eriantha *Jaub. & Sp. Ill. I, 145, t. 78.*—Loc.: Benn Chah, 20 miles N. of Surab, about 6200 ft. (no. M 385; Surab, 28° 29′ N, 66° 16′ E, about 5,700 ft. (no. M 379).

Vern. Name: Pihunpulli (Br.). This name means " white flower ", and is applied to lots of different plants.

Gaillonia hymonostephana *Jaub. & Sp. Ill. I, 146, t. 79,* var. **macrocalyx** *Blatt. & Hall. var. nov.*—Calyx post anthesim 12 mm diametro. Par foliorum summum infra calycem cum stipulis formans quasi involucrum hyalinum suaequalitor 6-lobum, lobis acutis, ovatis, uninerviis hispidulis. Rami foliaque minutim scabrida.

Loc.: Baranlak, 28 miles S. of Wad, about 4,100 ft. (no. 379). Fl. and fr. in Oct. 1917.

Gaillonia macrantha *Blatt. & Hall. spec. nov.*—Suffruticosa, ramosissima ramis erectis opposite et dichotome vel trichotome ramulosis. Rami albidi, ancipites vel trigoni propter folia opposita vel ternata decurrentia. Ramuli teretiusculi. delicatule striati, dense, minutim atque rigide pubescentes, olivacei. Folia opposita vel ternata, basi cum stipulis brevibus brevissime connatis, stipulis annulm formantibus,l ineari-subulata, atro-olivacea, apice subspinosa, usque ad 20 mm longa, infima et summa multo breviora, uninervia, rigide pubescentia, margine revoluta.—Flores terminales, cyman dichotomam vel trichotomam formantes. Calyx 5 mm longus, densissime hispidissime lanatus (multo densius quam in G. eriantha) ita quidem ut superficies conspici nequeat, tubulosus, 5-lobus usque ad medium, lobis lanceolatis acutis. Corolla hispida, tubo angustissimo, fauce valde ampliato, 5-loba, lobis oblongis obtusis. Stamina brevissima,

antheris apicem corollae attingentibus, filamentis insertis immediate infra sinus limbi corollae; stylus inclusus; stigma bifidum, glandulosum. Fructum non vidimus.

Differt a Gaillonia eriantha sequentibus: Rami sunt ancipites vel trigoni; Calyx et corolla multo hispidiores; annulus stipulis uniformibus tantum formatur.

Loc.: Near Quetta.—Fl. in Aug. 1918.

Gaillonia sp. Loc.: Hills S. of Chambar (Kolwa), 26° 9′ N, 64° 42′ E, about 2,000—2,200 ft. (no. M 259).

GALIUM *L.*

Galium aparine *L. Sp. Pl. 157.* Loc.: Khudabadan, ¼ mile N. of Panjgur, about 3,100 ft. (no. M 178).—Fl. and fr. in March 1918.

Vern. Name: Lichok (Bal.). Sticks to hands and clothes, which probably explains the name, "lich" being clinging mud. They say "lich" or "malich" to a camel on muddy ground, meaning "slippery" or "don't slip".

Compositae

VERNONIA *Schreb.*

Vernonia cinerea *Less. in Linnaea, IV, 291 and VI, 673.*— Loc.: Kanoji, 47 miles N. of Las Bela, about 3,200 ft. (no. 383); Chibi, about 63° 8′ E, 26° 19′ N., about 1,600 ft., growing in and on border of irrigation channels (no. M 125); Hills of Chambar (Kulwa), 26° 9′ N, 62° 42′ E, about 2,000 ft. (no. M 194 A).—Fl. and fr. in March and April 1918.

Vern. Name: Aghud (Br.).

ADENOSTEMMA *Forst.*

Adenostemma viscosum *Forst. Char Gen. (1776) 90.*—Loc. Near Ornach, about 3,300 ft. (no. 315). Fl. and Fr. in May 1917.

Vern. Name: Wal.

GNAPHALIUM *L.*

Gnaphalium pulvinatum *Del. Fl. Aegypt. 122, t. 44, f. 1.*—Loc.: Nag (W. Kolwa), about 83 miles E. by N. of Turbat, about 2,300 ft. (no. M 242); North Parpuki Kaur, 12 miles SSW of Panjgur, about 3,300 ft. (no. M 197); Ispikan, 16 miles NE of Mand, about 1,050 ft. (no. M 79);—Fl. and fr. in March and April 1918.

INULA *L.*

Inula grantioides *Boiss. Fl. Or. III, 195*; Loc: Between Msshkai and Pirandar Valley, about 2,500 ft. (no. 248); Awaran, 26° 24′ N, 65° 12′ E, about 1,750 ft. (no. M.2B).—Fl. and fr. in April 1918.

Vern. Names: Kolmir, Kolbur (Br.), Kolmir (Bal.).

PULICARIA *Gaertn.*

Pulicaria glaucescens *Jaub. and Sp. III. t. 349.*—Loc.: Rari Ban, 170 miles S. by W. of Kalat, 2,300 ft. (no. 284); Gwambuk, about 60 miles S. by E. of Panchgur, about 2,700 ft. (no. M 19B).—Fr. in April 1918.

Vern. Names: Kunchito (Bal.), Kunchid (Makrani Bal.), Ler Mazonk (Br.).

Pulicaria Boissieri *Hook. f. in Hook. f. Fl. Brit. Ind. III, 300.*—Loc.: Near Manguli, 197 miles SSW of Kalat, about 2,450 ft. (no. 242); Gwambuk, about 60 miles S. by E. of Panjgur, about 2,700 ft. (no. M 19C.)

Vern. Name: Kunchito (Bal.).

Pulicaria carnosa *Burkill in Working List Fl. Pl. Baluchistan (1909) 39.*—Loc.: Padigazu, 40 miles SSW of Panjgur, about 2,700 ft. (no. M19). Fr. in Dec. 1919.

Uses: Very favourite camel grazing; has a strongly apperient effect. Horses will eat it at a pinch. The effect in them is not marked (Hotson).

Vern. Name: Kunchid.

Pulicaria crispa *Benth. in Gen. Pl. II, 336.*—Loc.: Teghab (no. 190); Kochau 122 miles SW of Kalat, 4,150 ft. (no. 5 A); Pirandar, 205 miles SSW of Kalat, about 1,900 ft. (no. 24C); Shambaz Kalat, about 24 miles SSW of Panjgur, about 2,800 ft. (no. M199); Rek Chah, 11 miles E of Chambar (Kolwa) about 1,800 ft. (no. M133C); Panjgur (no. M133D); Hills S. of Chambar (Kolwa) 26° 9′ N, 64° 42′ E, about 2,000 ft. M133B); Mohtaji Kand, about 22 miles SW of Panjgur, about 2,800 ft. (no. M133, M133A).—Fl. and fr. from March to May 1918, from Aug. to Sept. 1917.

Uses: The plant is boiled and the liquid given to children in whose stomach milk turns sour.

Vern. Names: Boraku (Bal.), Rambo (Br.), Pihupulli (Br.), Bo-i-Madaran (Bal. Br.).

Pulicaria sp. Loc.: Turbat (no. M2); Ispikan, 16 miles NE of Mand, about 1,050 ft. (no. M2A). Fl. and Fr. in March 1918.

Vern. Names: Kolmir (Bal.), Kolbur (Br.).

Xanthium *L.*

Xanthium strumarium *L. Sp. Pl. (1753) 987.*—Loc.: Surab, 43 miles S. of Kalat, 5,750 ft., grows beside irrigation channels (no. 106). Fr. in Aug. 1917.

Uses: Said to be useless and only eaten by goats.

Vern. Name: Bichudi (Br.).

Eclipta *L.*

Eclipta erecta *L. Mantiss. II (1771) 286.*—Loc.: Jebri, 147 miles SSW of Kalat, 3,850 ft. (no. 221); Nag (W. Kolwa), about 83 miles E. by N. of Turbat, about 2,300 ft. (no. M 235. M 235 A); Zidi, 15 miles ESE of Khozdar, about 3,600 ft. (no. 355); Gajar, 165 miles SSW of Kalat, 3,450 ft. (no. 221 A); grows in water channels in cultivation. Fl. and fr. in Aug. and Sept. 1917.

Vern. Names: Bikgur (Br.), Murida (Bal.).

Achillea *L.*

Achillea Santolina *L. Sp. Pl. 1,264.*—Loc.: Near Quetta; Kalat, about 6,350 ft. (no. M399, M399 B).—Fl. and fr. in July 1918.

Vern. Name: Known in Kalat under the name of Bo-i-Madaran, which is the name for a Pulicaria.

MATRICARIA *L.*

Matricaria chamomilla *L. Sp. Pl. 1,256.*—Near Quetta.—Fl. and fr. in Aug.

SENECIO *L.*

Senecio coronolifolius *Desf. Atl. II, 273.*—Loc.: Harbud, about 55 miles E. of Panjgur, about 3,700 ft. (no. M 310, M 310 A).—Fl. and fr. in April 1918.

Vern. Name: Zardphul (? Bal.).

TANACETUM *L.*

Tanacetum fruticulosum *Ledeb. Fl. Alt. IV, 58, Ic. t. 38.*—Loc.: Zayaki Jangal 27° 54′ N, 65° 51′ E, about 4,600 ft. (no. M343); Spani, 59 miles S. of Kalat, 5,300 ft. (no. 13E); Harboi, 18 miles ESE of Kalat, 9,000 ft. (no. 13 B) Kuchkan, about 17 miles WSW of Panjgur, about 2,900 ft. (no. M 136, M136 A).—Fl. and fr.: March 1918.

Uses: Excellent sheep fodder. Camels will eat it, but get little profit. Soaked in cold water makes a decoction; very good for colds.

Vern. Name: Drana (Bal.), Drani (all Brahuis, especially Noshki), Butau (Brahuis of Kalat), Jir (Br.).

ARTEMISIA *L.*

Artemisia scoparia *Waldst. and Kit. Descr. et Ic. Pl. Rar. Hung. I (8802) 66, t. 65.*—Loc.: Shambaz Kalat, about 24 miles SSW of Panjgur, about 2,800 ft. (M 176 A); Wad, 27° 20′ N, 66° 20′ E, about 4,000 ft. (no. 1 A); Wahir, about 24 miles S. by W. of Khozdar, about 4,200 ft. (no. 367).—Fr. in Oct. 1917.

Vern. Names: Khisunjir (Br.), Luling (Br.), Jir (Br.), Gwatag (Bal.).

OTHONNOPSIS *J. & S.*

Othonnopsis intermedia *Boiss. Fl. Or. III, 414.*—Loc.: Shandadzai, 72 miles S of Kalat, 5,100 ft. (no. 17 B); Zayaki Jangal, 27° 54′ N, 65° 51′ E, about 4,600 ft. (no. M 344); Harboi, 9,000 ft. (no. 17).

Uses: The plant is used as a poultice for the chest. The leaves are made into a paste with oil. They are then spread on a large chapati and laid on the head of a man suffering from cold or fever. (Hotson).

Vern. Name: Manguli (Br., Bal.).

ECHINOPS *L.*

Echinops echinatus *DC. in Wight Contrib. 24.*—Loc.: Chhuttok, 90 miles S. of Kalat, 4,500 ft. (no. 174).

Echinops vilosissimus *Bge. Syn.* in Bull. Acad. Petrop. *VI 383.*—Loc.: Pishuk, 27° 33′ N, 65° 18′ E, about 5,300 ft. (no. M 342); Panjgur, about 3,100 ft. (no. M 320). Fr. in May 1918.

COUSINIA *Cass.*

Cousinia minuta *Boiss Fl. Or. III, 489.*—Loc.: One mile NE of Panjgur (no. M 170 A).—Fr. in May 1918.

Vern. Name: Kemar (Bal.).

Cousinia multiloba *DC. Prodr. VI, 554.*—Loc.: Surab, 28° 25′ N, 69° 16′ E, about 5,700 ft. (no. M 381).

CENTAUREA *L.*

Centaurea calcitrapa *L. Sp. Pl. 1,297.*—Loc.: Kalat, about 6,350 ft. (no. M 371 B, M 398A); Surab, 28° 29′ N, 66° 16′ E, about 5,700

ft. (no. M371A); Iskalku, 7 miles E. of Kalat, 7,500 ft. (no.11); Surab, 43 miles S. of Kalat 5,750 ft. (no.'115).—Fl. and fr. in June 1918, July and Aug. 1917.

Uses: Eaten only by camels, not by donkeys.

Centaurea picris *Pall. in Willd. III, 2,302.*—Loc.: Kalat, about 6,350 ft. (no. M389A).—Fl. and fr. in July 1918.

Vern Name: Talkh Kah. (Br.).

Cichorium *L.*

Cichorium Noeanum *Boiss. Fl. Or. III, 717.*—Loc.: Kalat, about 6,300 ft. (no. M 366B); Surab, 43 miles S. of Kalat, 5,750 ft. (no.12A); Iskalku, 7 miles E of Kalat, 7,500f t. (no. 12); Sitani, 28° 19' N, 66° 5' E, about 5,300 ft. (no. M366); Surab, 28° 29' N, 66° 16' E, about 5,700 ft. (no. M366A). Iskalku is about the highest level at which Hotson has observed this plant. Common near irrigation channels at lower levels.—Fl. and fr. in June and July 1918, Aug. 1917.

Uses: The flowers are soaked in water and the water used for sore legs, and also for a stomach derangement called "dik" (Hotson).

Vern. Names: Kashni, Kashnen, Talka kah (Br.).

Koelpinia *Pall.*

Koelpinia linearis *Pall. Itin. App. 755.*—Loc.: Sarchib, about 628. 40' E, 26° 16' N, about 1,900 ft. (no. M 116, M 116A); near Quetta. —Fl. and fr. in March 1918.

Vern. Name: Zampad (Bal.).

Taraxacum *Juss.*

Taraxacum officinale *Wigg. Prim. Fl. Hols. 56.*—Loc.: Kalat,about 6,300 ft. (no. M 149D); Surab, 43 miles S. of Kalat, 5,750 ft. (no. 9 C, 9D); Iskalku, 7 miles E. of Kalat, 7,500 ft. (no. 9); Harboi, 18 miles ESE of Kalat, 8,600 ft. (no. 9B); Teghab, 107 miles S. of Kalat, 4,150 ft. (no. 185)—Fl. and fr. in July 1918, Aug. 1917.

Uses: The leaves are eaten raw.

Vern. Names: Halako (Br. Bal.), Pochku, Pochaku, Bahi (Br.), Aghud (Br).

Taraxacum officinale var. genuinum *Koch Syn. 492.*—Loc.: Surab, 28° 29′ N, 66° 16′ E, about 5,700 ft. (no. M 381).—Fl. and fr. in July 1918.

Vern. Name: Chambar (Br.).

Lactuca *L.*

Lactuca scariola *L. Sp. Fl. 1119.*—Loc.; Panjgur (no M 102 E); Zidi, 15 miles ESE of Khozdar, about 3,600 ft. (no. 352).—Fl. in May 1918.

Lactuca viminea *J. & C. Presl. Pl. Cech. 160.*—Loc. Surab, 28° 29′ N, 66° 16′ E, about 5,700 ft. (no. M83E).—Fl. and fr. in July 1918.

Vern. Names: Khargoshkah (Bal.), Murubahi (Br.).

Lactuca remotiflora *DC. in Wight Contr. 1,834, 26.*—Loc.: Nokabad in Kulbar Valley, 19 miles NE of Mand, about 1,200 ft. (no. M102).—Fl. in March 1918.

Vern. Name: Pochaku (Bal.).

SONCHUS *L.*

Sonchus oleraceus *L. Sp. Pl. 1753. 794.*—Loc.: Sitani, 28° 19′ N, 66° 5′ E, about 5,300 ft, (no. M149 C). Growing beside irrigation channels.—Fl. and fr. in June 1918.

Vern. Name: Aghud (Br.).

Sonchus asper *Hill Herb. Brit. I (1769) 47.*—Loc.: Near Quetta.—Fl. in August.

Sonchus arvensis *L. Sp. Pl. (Pl. 1753) 1793.*—Loc.: Surab, 43 miles S. 1,753 of Kalat, 5,750 ft. (no. 114).—Fl. and fr. in August 1917.

LAUNAEA *Cass.*

Launaea chondrilloides *Hook. f. Fl. Brit. Ind. III (1881) 415.*—Loc.: Hodal Pass (N. side), about 80 miles S of Panjgur, 2,200—2,500 ft., common nearly everywhere (no. M 114B).

Vern. Names: Mahari, Halaku (Bal.).

Launaea nudicaulis *Hook f. Fl. Brit. Ind. III (1881) 416.*—Loc.: Hushtar Rahi Kaur, 160 miles S of Kalat, about 3,700 ft. (no. 185A); junction of Raghai and Sichk rivers, about 3,600 ft. (no. M305); Hodal Pass (N. Side), 80 miles S. of Panjgur 2,200—2,900 ft, (no. M83B); Rodkan (no. M83D); Chibsar, about 62° 40′ E, 26° 16′ N, about 1,900 ft. (no. M114); Surab 43 miles S. of Kalat, 5,750 ft. (no. 109); Panjgur (no. M 102 I); Rodkan (W. Kolwa), about 85 miles E. of Turbat, about 1,800 ft. (no. M83C); Nagak (W. Kolwa), about 87 miles E. by N. of Turbat, about 2,400 ft. (no. M102B); Sarchib, about 62° 40′ E, 26° 16′ N, about 1,900 ft. (no M115).—Fl. and fr. from March to May 1918.

Vern. Names: Halaco, Marubahi (Br.), Halaku, Mahari halaku, Machi malaku Reki halaku, Khargoshkah, Kakoshonk (Bal.).

Launaea glomerata *Hook. f. in Fl. Brit. Ind. III (1881) 417.*—Loc.: Harbud, about 55 miles E of Panjgur, about 3,700 ft. (no.M115B); junction of Raghai and Sichk rivers, about 3,600 ft. (no. M102D); Panjgur (no. M102G); Garmkan, 1 mile NE of Panjgur, about 3,125 ft. (no. M62A).—Fl. and fr. in April and May, 1918.

Vern. Names: Reki halaku, Machi halako (Bal.).

SCORZONERA *L.*

Scorzonera sp.—Loc.: Panjgur (no. M102H)

Vern. Name: Halaku.

Primulaceae.

ANAGALLIS *L*

Anagallis arvensis *L. Sp. Pl. (1753).* 148.—Loc.: Panjguri, about 3,100 ft. (no. M 151); Nag (W. Kolwa), about 83 miles E. by N. of Turbat, about 2,300 ft.—Fl. and fr. March and April 1918.

Vern. Names: Makui (Sindhi), Makui (Bal.), Boraku (Br.). All these names are doubtful.

Oleaceae.

OLEA *L.*

Olea ouropaea *L. Sp. Pl. I, 11.*—Loc.: Near Ornach, about 3,400 ft. (159B); Halgali Pass (no. M 350A).—Fr. in Sept. 1917.

Vern. Names: Khat, Khat sakar.

Olea cuspidata *Wall. Cat. no. 2817.*—Loc.: Rar Kaur, about 185 miles S. by W. of Kalat, up to 4,000 ft. (no. 159A); Kalgali Pass, about 3,400 ft. (M 350); Ornach, about 27° 0′ N, 66° 10′ E.

Uses: These trees are in countless numbers on the Hushtar Rahi Pass, which includes the upper part of the Rar Kaur on the W. or Pelar side and of the Hushtar Rahi Kaur on the E. or Ornach side. I did not notice how low the trees began, probably about 3,000 ft. Those bearing fruit were higher, at the summit of the Pass, nearly 4,000 ft. and on the hills on either side, several hundred feet higher. There are literally tons of berries, and no use is made of them. A few are eaten, but they are not exported, nor is the oil pressed out. Their flavour is pleasant, but scarcely characteristic, sweet at first, with a slightly bitter aftertaste. (Hotson).—Fr. in September 1917.

Vern. Names: Zaitun (Pers. Bal. Br.), Jhak (Bal Br.), Khat (Br.).

Salvadoraceae.

SALVADORA *L.*

Salvadora persica *L. Sp. Pl. (1753) 122.*—Loc.: Near Manguli, 197 miles SSW of Kalat (no. 236); very common below Gwarjak; Kaur Dat, 10 miles N of Rekin, about 1,900 ft. (no. M 36B); Hills S. of Chambar (Kolwa), 26° 9′ N, 64° 42′ E, about 1,800-2,300 ft. (M 86A).—Fl. in April 1918.

Vern. Names: Kabar (Bal. etc.), Toj (Bal.), Kabad.

Salvadora oleoides *Decne. in Jacq. Voy. Bot. (1844) 140, t. 144.*—Loc.: Hills near Ispikan, about 20 miles NE of Mand, about 1,200-1,500 ft., everywhere the Kabar is yellow with young leaves. (no. M 86).—Fl. in March 1918.

Vern. Name: Kabar (Bal. Br. Sindhi, etc.).

Apocynaceae.

RHAZYA *Dcne.*

Rhazya stricta *Decne. Ann. Sc. Nat. ser. II, 4, p. 80.*—Loc.: Zahrenkahur, 16 miles N. of Pasni, about 200 ft. (no. M.37); Wahir, 25 miles S. by W. of Khozdar, about 4,200 ft. (no. 155A bis).—Fl. in Sept. 1917, Feb. 1918.

Vern. Names: Heshar, Eshar (Makrani Bal.), Heshwark, Heshwark (Br.).

NERIUM *L.*

Nerium odorum *Sol. in Herb. Kew ed. I, 296.*—Loc.: Chuttok, 90 miles S. of Kalat, 4,500 ft. (no. 175); Ghulamani Bent, about 21 miles N. of Pasni, about 120 ft. (no. M 50).—Fl. in Feb. 1918, Aug. 1917.

Uses: When eaten fatal to animals.

Vern. Name: Jaur (Bal. Br.)

Asclepiadaceae.

HEMIDEMSUS *R. Br.*

Hemidesmus indicus *R. Br. in Mem. Wern. I (1811) 57.*—Loc.: Near Manguli, 197 miles SSW of Kalat, about 2,450 ft. (no. 245).

Vern. Name: Wal (Bal. Br.).

PERIPLOCA *L.*

Periploca aphylla *Decne. in Jacquem. Voy. Bot. (1844) 109, t. 116.* —Loc.: Taloi Sunt, 11 miles N. of Pasni, about 50 ft. (no. M84); Rari Dan, 170 miles S. by W. of Kalat, 2,300 ft. (no. 158A); Gidardhor, about 80 miles S. of Kalat, about 4,900 ft. (no. 158); E. side of Burida Pass, nearly 140 miles SSW of Kalat, below 4,250 ft. (no. 158 A bis).

Uses: Excellent camel fodder.

Vern. Names: Hum (Br.), Gishtar (Bal.).

GLOSSONEMA *Dcne.*

Glossonema varians *Benth. in Benth. & Hook. f. Gen. Pl. II (1876) 748.*—Loc.: Khozdar, 27° 48′ N, 66° 37′ E, about 4,100 ft. (no. 350); near Sitani, 59 miles S. of Kalat, 5,300 ft. (no. 126, 129); near Ornach, 27° 0′ N, 66° 10′ E, about 3,000 ft. (no. 143 B); Mandi Parak, about 22 miles E. of Chambar (no. M 274); Gar Pass, about 23 miles E. by S. of Panjgur, about 4,200 ft. (no. M 274A).—Fl. in Sept. 1917.

Uses: The follicles are cooked and eaten as vegetable.

Vern. Names: Khuromb, Gavaluk, Gavalok (Br.), Kundu (Bal.), Mashana Galau (Br.).

CALOTROPIS *R. Br.*

Calotropis procera *R. Br. in Ait. Hort. Kew, ed. 2, II (1811) 78.*—Loc.: Teghab, 107 miles S. of Kalat, 4,150 ft. (no. 189); Las Bela, about 700 ft. (no. 399).— Fl. in Aug. 1917.

Vern. Names: Arakh (Br.), Karg (Bal.).

OXYSTELMA *R. Br.*

Oxystelma esculentum. *R. Br. in Mem. Wern. Soc. I (1811) 40.*—Loc.: Gajar, 165 miles SSW of Kalat, 3,450 ft. (no. 230); Korak (Pelar), 180 miles S. by W. of Kalat, about 1,900 ft. (no. 230B).—Fl. in Sept. 1917. Fr. in Sept. 1917.

Vern. Name: Wal (Bal. Br.).

Oxystelma Alpini *Dcne. in DC. Prodr. VIII, 543.*—Loc.: Korak (Pelar) 180 miles S. by W. of Kalat, 1,900 ft. (no. 230 A).—Fl. in Sept. 1917.

Vern. Name: Wal (Bal. Br.).

PENTATROPIS *R. Br.*

Pentatropis cynanchoides *R. Br. in Salt Voy. Abyss. (1814) App. 64.*—Loc.: Near Kuldan (W. Kolwa) about 85 miles E. by N. of Turbat, about 2,400 ft. (no. M232); Hills S. of Chambar (Kolwa), 26° 9′ N, 64° 42′ E, about 1800—2,200 ft. (no. M232A).—Fl. in April 1918.

Uses: The leaves are soaked in hot milk, then the liquid is gently pressed out and used as a wash for sore eyes.

Vern. Name: Aichk (Bal. Br.).

DAEMIA *R. Br.*

Daemia cordata *R. Br. in Mem. Wern. Soc. 1 (1809) 50.*—Loc.: Below Bhani, 131 miles SSW of Kalat, nearly 4,000 ft. (no. 208); Hodal Pass (N. side), 80 miles S. of Panjgur 2,200—2,900 ft. (no. M223); South Parpuki Kaur, 17 miles S. by W. of Panjgur, about 3,400 ft.

(no. M198); Hills S. of Chambar (Kolwa), 26° 9′ N, 64° 42′ E, about 1,800—2,200 ft. (no. M263); Barit Pass, between Pirandar and Nunbara, about 2,000 ft. (no. 266).—Fl. and fr. in April and March 1918.

Uses: The juice is said to be harmful to the skin. I did not observe this. (Hotson).

Vern. Names: Xohi Wal (Bal.), Wal (Br.), Shiter (Bal.).

CYNANCHUM *L.*

Cynanchum Arnottianum *Wight Contrib. 58.*—Loc.: Bizhban Chah (Gichk) about 40 miles E. of Panjgur, about 3,775 ft. (no. M316); Surab, 43 miles S. of Kalat, 5,750 ft. (no. 102); Surab, about 28° 29′ N, 66° 16′ E, about 5,700—5,900 ft., by the sides of irrigation channels (no. M373A); Benn Chah, 21 miles N. of Surab, about 6,200 ft. (no. M373A bis).—Fl. from April to July 1918, in August 1917. Fr. in June 1918.

Uses: The leaves are dried in the shade, not in the sun, and ground to powder: they are then applied to wounds on animals in which there are maggots, and the maggots die. (Hotson).

Vern. Names: Jauri kani, Kuri (Br.), Bhankalink (Bal.).

Cynanchum acutum *L. Sp. Pl. 212.*—Loc.: Panjgur, about 3,100 ft. (no. M232B); below Bhani, 131 miles SSW of Kalat, nearly 4,000 ft. (no. 207); Gajar, 165 miles SSW of Kalat, 3,459 ft. (no. 229) —Fl. in August and September 1917.

Vern. Names: Wal (Br. and Bal.), Aichk (Bal.), Auishk (Br.), Ushkunpan (Br.), Shangrati (Jangli).

PERGULARIA *L.*

Pergularia pallida *Wight & Arn. in Wight Contrib. (1834) 42.*—Loc.: Rar Kaur, about 165 miles S. by W. of Kalat, about 2,600 ft. and higher to near summit, nearly 4,000 ft. (no. 292A); on March 47 to 12 miles N. of Las Bela, 3,500 ft. to 1,000 ft. (no 397); a climber, generally on Tamarisk.—Fl. in Sept. and Oct. 1917. Fr. in Oct. 1917.

Vern. Name: Manja Wali (Bal.).

LEPTADENIA *R. Br.*

Leptadenia Spartium *Wight Contrib. (1834) 48.*— Loc.: Kalgali Kaur, 28° 2′ N, 65° 52′ E, about 5,350 ft. (no. M351); growing among rocks.—Fl. in June 1918.

Vern. Name: Ritachk, Lapar (Br.).

BOUCEROSIA *Wight & Arn.*

Boucerosia Aucheriana *Dcne. in DC. Prodr. VIII, 649.*—Loc.: Near Gajar, 165 miles SSW of Kalat, 3,450 ft. (no. 231); Gwambuk about 50 miles S. by E of Panjgur, about 2,700 ft. (no. M30); Manguli, 26° 45′ N, 65° 21′ E, about 2,600 ft. (no. M30A, M30B).

It has an astringent taste; is eaten raw as a medicine for all sorts of complaints, or cooked as a vegetable. (Hotson).

Vern. Name: Marmot (Br.).

(To be continued.)

CURRENT LITERATURE.

Distribution

Becari, O., The Palms of the Philipine Islands, *Philippine Journal of Science XIV No. 3, (March 1919) pp. 295-362*, 3Pl.

The author gives a list of the palms of these islands with notes on points of special interest, and descriptions of new species; and prefaces it with a general survey. The number of species at present known is 120, of which about 20 are non-endemic and for the most part belong to the littoral swamps of neighbouring countries. Nearly all the endemic species belong to Malayan genera. The great bulk of the palm flora belong to the genera *Pinanga, Areca, Calamus and Daemerops.* Of the 36 known species of *Areca* no fewer than 10 are characteristically Philippine ones, and from the occurrance here of closely allied species, and their absence elsewhere, the author considers that *Areca catechu* acquired its specific characters in these islands.

P. F. F.

Evolution

Arber, Agnes, The Law of Loss in Evolution—*a paper read before the Linnaean Society No. 7th, 1918 and, abstracted, in Proc. Linn. Soc. Lond. Oct. 1919. pp. 70-78.*

Mrs. Arber in this paper formulates under the name of the 'Law of Loss' a principle which appears to have operated in the evolution of plants. By this she means the general rule that "a structure or orgen once lost in the course of phylogeny can never be regained; if the organism subsequently has occasion to replace it, it cannot be reproduced, but must be constructed afresh in some different mode." As instances of the working of this Law of Loss, though in the nature of things formal proof cannot be given, she points out that certain water-plants, *Ceratophyllum* and *Utricularia sp.*, are entirely rootless even as seedlings, and since the evidence is all in favour of a terrestrial origin of the Flowering Plants we are driven to the conclusion that these plants have lost the power of producing roots, and that in both the need of an absorbing organ has reasserted itself and has been met, not by the re-establishment of true roots, but by the development of special subterranean shoots which act as roots. Again it seems probable that the Monocotyledons, derived, as we have good reason now for believing, from a dicotyledonous ancestor, have lost the property of forming a true leaf-lamina, so that their leaves consist of base and stalk, or even leaf-base alone; when an attemt is made to produce a compound leaf, it isiby a totally different method. As another instance she points out that Flowering Plants are considered to have been derived ultimately from a fern-stock in which the male gamete, in harmony with its aquatic life, is ciliated; but the submerged flowers of present-day phanerogams have merely slightly modified pollen grains which are dependent on currents in the water to find the ovules, the art of producing cilia having been lost. Other instances are the pappus scales of certain Compositæ which there is good reason to believe are hairs, not modified sepals, and Small has given reasons for supposing that this order was derived

from certain of the Lobelideae in which the calyx may have been entirely absent. Yet another instance is the formation of the reserve food (endosperm) of the angiosperm seed out of apparently a second embryo which has been spoilt by the fusion of its nucleus with the polar nucleus, in order to replace the gametophyte, which, reduced in Gymnosperms, had disappeared perhaps with the necessity for limiting the size of the ovules in the closed carpel. The peculiar secondary thickening of the larger Monocotyledons and the polystely of *Gunera* may be explained on the same lines *i.e.* that the original mode of thickenning has been lost, and when in the course of evolution the necessity for a thicker stem again arose, had to be replaced by a different method. On this hypothesis too she suggests, that the floral envelope of *Nais* is not a reduced perianth, still less a rudimentary one, but a new structure evolved to take the place of a lost perianth. The new Law is thus in accord with the view that the primitive angiosperm flower was of the type now in the *Ranales*, and is not to be found among the Archichlamydeæ, as assumed in the 'continental' systems of Eichler and Engler, and affords pleasing support for the older system of the *Genera Plantarum* of Bentham and Hooker, in so far at least that in it the *Ranunculaceæ* were placed first, and the *apetalae* last of the Dicotyledons with the Monocotyledons after. Mrs. Arber supports her hypothesis with instances drawn from the evolution of animals, in which the Law of Loss had previously been enunciated in another form. The essay is most interesting and suggestive, and well worth attention. It is in conformity with the idea of the absoluteness of inheritance, towards which so much modern work seems to point.

P. F. F.

Histology

McLean, R. C. Sex and Soma.

This was the title of a communication read at a meeting of the Linnaean Society on November 20th, 1919, with reference to the occurrence of multinucleate cells in higher plants, as described especially by Dr. Arber and Dr. Beer, in a paper which was abstracted in the November issue of this journal, p. 94. The papers has not appeared in print, and the following is taken from the published minutes of the meeting.

"The Author enlarged upon the recently discovered phase of multinucleosis in the developing soma cell of higher plants and maintained, in opposition to Arber and Beer, that there is evidence of nuclear reunions taking place in the multinuclear cells. He characterized these fusions as modified sexual conjugations consequent upon the long series of vegetable divisions in the lineage of a soma cell, and necessary to avoid the degeneration which experiment shows to be attendant upon prolonged vegetative propagation. The development of the plant body may thus be regarded as embracing two phases of stimulus: firstly, the normal sex stimulus which initiates the period of maximum cell proliferation, and, secondly, this somatic nuclear union, initiating the period of maximum differentiation. Tissue differentiation, it was suggested, may be associated with some process of segregation subsequent to this nuclear fusion . . . It was finally suggested that germinal modifications as well as somatic segregations may be derived from a mechanism of nuclear fractionization and subsequent partial reunion in somatic cells."

P. F. F.

Hepaticae

Evans Alexander W. A Taxonomic Study of Dumortiera *Bulletin of the Torrey Botanical Club, Vol. 46, No. 5, (May 1919).*

The writer gives a historical account of the genus, and fully examines critically the various characters which have been used by various writers on this genus. Stephani recognised three species in his species *Hepaticarum* in 1899 and Campbell published last year the description of a fourth species. The writer however recognises only two species on the basis of the characters drawn from the structural features of the vegetative thallus, and says that the characters "drawn from the size and method of branching of the thalus seem especially unreliable, Those drawn from the female receptacle and the spores are scarcely more satisfactory." The writer has examined a very large number of specimens and gives a full list of synonyms and the places from which the plants came. The following is the key which he gives:—

Upper surface of the thallus smooth or nearly so throughout (although often showing vestigial air chambers). D. hirsuta.

Upper surface of the thallus with crowded papilliform cells, at least in certain portions (always showing vestigial air chambers). D. nepalensis.

S. R. K.

Allen, E. R., Some Conditions Affecting the Growth of Azotobacter chroococcum. *Annals of the Missouri Botanical Garden, Vol. VI. No. 1, p. I (Feb. 1919).*

The Nitrogen-fixing bacterium *Azotobacter* has since its discovery by Beijerinck in 1901 been the subject of considerable study; and it has been found by many workers that growth in ordinary synthetic culture media is poor, but that an aqueous extract of soil or even tap—instead of distilled water causes a marked improvement. Kzyemieniewski, in 1908, found that the humus was the important constituent of soil, and several suggestions as to the meaning of this have been made. One is that the beneficial result is due to the presence of iron and aluminium-silico-phosphates, but as the optimum quantity of the former lies at 10 mg per 100 cc, and is thus considerably above that which would be required for nutrition, H. Fischer suggested that the role of humus or of the $Fe_2 O_3$ is that of an oxygen carrier. Bottomly in 1914 suggested that certain bodies, analagous to vitamines and which he called 'auximones', are liberated from peat treated with certain anoerobic bacteria, and that there auximones are the cause of the action of humus in cultures of Azotobacter. In the paper under notice the author describes experiments which point to the need of phosphorus and the absence of all acid in the culture-medium as the chief requirements, and that it is unnecessary to postulate the action of colloidal oxygen carriers or of any special and rare or supposed constituents or products of the soil-humus such as anximones.

P. F. F.

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P. F. FYSON, B.A., F.L.S.

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THE

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VOL. I. MARCH, 1920. NOS. 6 & 7.

THE PHYSIOLOGICAL ANATOMY OF THE PLANTS OF THE INDIAN DESERT

BY

T. S. SABNIS, B.A., B.Sc.

St. Xavier's College, Bombay.

(*Continued from p. 109.*)

ZYGOPHYLLACEAE.

Tribulus terrestris *L.*—Figs. 68, 69, 70. Epidermal cells tabular with outer and inner walls convexly arched outwards and inwards, respectively. Guard-cells elevated. Veins embedded and provided with bundle-sheaths, of thick-walled chlorophyll containing cells. Mesophyll composed of palisade tissue on the adaxia side and of subepidermal aqueous layer and palisade tissue on the abaxial side. Clustered crystals occurring in the leaf and axis. Clothing hairs unicellular on the leaf and axis. Primary cortex forming an aqueous tissue. Wood composite. Wood prosenchyma enclosing the end of the xylem bundles. Pith formed of thick-walled cells.

Tribulus alatus *L.*—Epidermal cells tabular with outer and inner walls convexly arched outwards and inwards respectively. Outer walls superficially granulated. Guard-cells elevated. Mesophyll formed of palisade tissue on the adaxial side and subepidermal aqueous layer and palisade tissue on the abaxial side. Veins embedded and provided with bundle-sheaths of thick-walled chlorens chymatous cells. Clustered crystals in the leaf and axis. Wood composite. Wood parenchyma enclosing the lower ends of the xylem bundles. Pith formed of thin-walled cells.

Seetzenia orientalis *Dene*—Figs. 71, 72, 73, 74. Epidermal cells tabular. Large water-storing cells intercalated amongst the ordinary epidermal cells. Stomata depressed. Mesophyll formed of

palisade tissue on the adaxial side and of arm-palisade tissue on the abaxial side. Veins not provided with bundle-sheaths. Clustered crystals occurring in the leaf and axis. Assimilatory tissue in the axis formed of chlorenchyma. Wood composite. Pith formed of thin-walled cells and forming occasionally an aqueous tissue.

Zygophyllum simplex *L.* Figs. 75, 76. Epidermal cells polygonal. Guard-cells elevated. Mesophyll composed of a subepidermal composite ring of palisade cells enclosing a massive aqueous tissue surrounding the central vascular bundles. Veins embedded. Peripheral veins numerous, strengthening the aqueous tissue and provided with sheaths of thick-walled cells, the outer ones containing chlorophyll and the inner ones containing clustered crystals. Veins traversing the aqueous tissue. T. S. of the axis kidney-shaped with angles projecting outwards at the grooved surface. Primary cortex forming an aqueous tissue. Wood composite. Pericycle distinctly isobilateral. Pith of thin-walled cells and forming an aqueous tissue. Clustered crystals numerous in the axis.

Fagonia cretica *L.* Figs. 77, 78. Epidermal cells with outer and inner walls convexly arched outwards and inwards. Outer walls superficially granulated. Guard-cells elevated. Mesophyll isobilateral. A group of palisade-like cells faintly green and perhaps with a water-storing function, occurring between the lower epidermis and the vein of the mid-rib. Oxalate of lime not occurring in any form. Veins embedded and provided with bundle-sheaths of thin-walled cells. Assimilatory tissue in the axis formed of palisade cells. Wood composite. Pith formed of thin-walled cells.

Structure of the Axis.—The epidermis consists of tabular cells with outer and inner walls convexly arched outwards and inwards respectively. The lateral walls are usually straight. The outer walls are superficially granulated in *Tribulus alatus*, *Fagonia cretica* and *Zygophyllum simplex*. Large water-storing cells are intercalated amongst the ordinary epidermal cells in Seetzenia orientalis (fig. 71). Epidermal cells are thin-walled; this can be accounted for by the fleshy character of the leaves.

The stomata occur on both the surfaces, though more numerous on the lower; they are surrounded by 3-6 ordinary epidermal cells. Guard-cells are elevated in species of *Tribulus*, *Fagonia cretica* *Zygophyllum simplex* (fig. 75), so that the front-cavity is on a level with the surface. In *Seetzenia orientalis* (fig. 72), the stomata are depressed and the guard-cells are either in the same plane or in a plane lower than that of the surrounding cells.

The elevated position of the stomata in species of *Tribulus* may be due to a protective covering of hairs and to the subepidamal

aqueous tissue on the lower side, in *F. cretica* to a comparatively extensive ventilating system and to the glandular nature of the plant and in *Zygophyllum simplex* to the abundance of aqueous tissue. The depressed position of the stomata in *S. orientalis* is perhaps due to the absence of aqueous tissue in the mesophyll.

The mesophyll in species of *Tribulus* (fig. 68) is composed of a layer of long palisade cells on the upper side and of a subepidermal layer of polygonal aqueous cells and a layer of short palisade cells on the lower; the middle tissue is represented by the chlorenchymatous cells of the bundle-sheaths. In the cylinderical leaves of *Z. Simplex*, the assimilatory tissue forms a subepidermal composite ring of palisade cells and encloses a massive aqueous tissue of large thin-walled cells, which surrounds the central vascular bundles. In *Seetzenia orientalis* (fig. 71) there is a two-layered palisade tissue on the adaxial side and a two-layered arm-palisade tissue on the abaxial side; the middle tissue consists of thin-walled polygonal cells, some of which contain clustered crystals. The mesophyll in *F. cretica* (fig. 77) is composed of palisade tissue on both the sides with the middle tissue represented by the bundle-sheath cells. *In F. cretica* there occur rounded groups of faintly green palisade-like cells, with perhaps a water-storing function, between the lower epidermis and the vein of the mid-rib. Internal secretory organs do not occur in any of the members.

Oxalate of lime occurs in the form of clustered crystals in the neighbourhood of the veins in species of *Tribulus*, *S. orientalis* and *Z. simplex* in which the inner cells of the sheaths of the peripheral veins mostly contain clustered crystals (fig. 75).

The veins are embedded and are provided with green bundle-sheaths. The sheath-cells are thin-walled and polygonal in *F. cretica*, they are cubical and thick-walled in the other members of the order. The veins are numerous in species of *Tribulus*, *F. cretica* and *Z. simplex*. The abundance of veins corresponds with the abundance of watery contents in the mesophyll. The peripheral veins in *Z. simplex* form a supporting network of veins for the massive aqueous tissue.

Hairy covering is present only on the leaf and axis, in species of *Tribulus*. It consists of simple unicellular hairs which are more numerous on the lower surface of the leaf (figs. 68, 69). External glands are not found on any of the members.

Structure of the Axis.—Epidermis in species of *Tribulus* consists of small thick-walled cells. The epidermal cells in *S. orientalis* are polygonal with outer and inner walls thickened and with lateral walls thin and undulated; there are large cells, perhaps with a water-

storing function, intercalated amongst the ordinary epidermal cells (fig. 73). Epidermal cells in *F. cretica* are tabular with outer walls thickened and cuticularised and with lateral walls thin and straight. Epidermis in *Z. simplex* is composed of polygonal cells with outer walls thickened and papillose. Outer walls are superficially granulated in all members except *T. terrestris*. The stomata are like those on the leaf.

The primary cortex in species of *Tribulus* is characterised by the presence of a layer of subepidermal collenchyma below which occurs cortical parenchyma with a water-storing function. The cortex in *S. orientalis* consists of chlorenchyma and forms an assimilatory tissue; it forms an aqueous tissue strengthened in the projecting angular portions by small stone-cell groups in *Z. simplex*. In *F. cretica* it consists on its outer side of an assimilatory tissue of palisade cells and of an inner portion of an aqueous tissue; it is strengthened by stone-cell groups which can be roughly arranged in three rings, the outermost groups being the largest and almost subepidermal in position and giving a ribbed appearance to the axis.

The pericycle is composed of rhomboidal groups of stone-cells in species of *Tribulus*, *S. orientalis* and *F. cretica*. The stone-cell tissue is extensive and is necessary to strengthen the massive cortical aqueous tissue. The pericycle in *Z. simplex* is composed of stone-cell groups and presents an isobilateral arrangement; the stone-cell tissue along the grooved portion is greatly reduced and consists of isolated stone-cells or of very small groups.

In prostrate axis of species of *Tribulus* and of *S. orientalis* the stone-cell tissue is more extensive along the upper portion of the axis. In spite of the prostrate habit of the axis of *F. cretica* the pericycle does not seem to be much affected except that the stone-cell groups are closer together on the upper side.

The structure of the wood presents an isobilateral appearance in all the members. Wood forms a composite hollow cylinder formed of closely placed xylem bundles. Interfascicular wood prosenchyma is little developed. Wood prosenchyma encloses the lower portion of the xylem bundles in *T. terrestris*, while in *T. alatus* it is replaced by wood parenchyma; this may form a specific difference. Medullary rags are absent except in *F. cretica* where uniseriate rays occur.

Along the upper surface which is more exposed to the sun and climatic factors and which consequently presents greater functional activity, the xylem bundles are larger with vessels larger and more numerous; on the lower side which is protected from the sun the xylem bundles are much smaller and the vessels smaller and less numerous.

The prostrate habit even affects the symmetry of the whole axis in *F. cretica* and *Z. simplex* where the axis is semi-terate and presents a kidney-shaped appearance in T. S., the grooved surface representing the side in contact with the substratum.

Soft bast forms a continuous ring and follows the outline of the wood cylinder. Oxalate of lime is found in the form of clustered crystals in the cortex and pith in the species of *Tribulus* and *T. orientalis*. Pith consists of thick-walled cells in species of *Tribulus* and *F. cretica*; in others it is composed of thin-walled cells. The pith in *S. orientalis* and *Z. simplex* may occasionally form an aqueous tissue.

General Review,—The plants are fleshy and characterised by the plasticity of the tissues as was seen in the different modifications introduced in the prostrate axis. Outer walls of the epidermal cells are not much thickened and are superficially granulated. There is abundance of aqueous tissue in the leaf and axis. Mesophyll is truly isobilateral and shows a distinct tendency to isobilateral symmetry. Hairs, when present, are unicellular. Guard-cells are elevated, so that the front cavity is on a level with the surface, with the exception of *S. orientalis*, where the stomata are depressed. The veins, are embedded and provided in some members with distinct bundle-sheaths. Oxalate of lime-occurs in the form of clustered crystals in the leaf and axis.

The assimilatory tissue is composed either of palisade cells or of chlorenchyma or is absent, in which latter case the primary cortex functions as an aqueous tissue. The pericycle is composed of groups of stone-cells and presents an isobilateral structure. Wood forms a composite hollow cylinder. Medullary rays occur only in *F. cretica* and are uniseriate. The size of the xylem bundles and the size and abundance of vessels vary on the upper and lower surface of the prostrate axis. Soft bast forms a continuous ring and follows the outline of the wood cylinder.

The pith is composed of thick-walled or thin-walled cells. In the latter case the pith may occasionally form an aqueous tissue.

GERANIACEAE.

Monsonia heliotropioides *Boiss.*—Plate X figs. 79, 80, 81. *Leaf only.* Epidermal cells polygonal with outer walls papillose, especially so on the lower surface. Inner and outer walls equally thickened. Stomata occurring on both the surfaces and surrounded by ordinary epidermal cells. Guard-cells elevated. Mesophyll formed of greatly elongated palisade cells on the upper side and of arm-palisade tissue on the lower. Internal glands absent. Clothing hairs unicel-

lular and with muriculate walls. Glandular hairs formed of a short uniseriate stalk and of an obconical unicellular head. Oxalate of lime found in the form of clustered crystals. Leaf many-ribbed. Veins of the ribs vertically transcurrent. Smaller veins embedded.

Structure of the Leaf.—The epidermal cells are polygonal with outer walls papillose much more so on the lower surface. The outer and inner walls are equally thickened. Inner walls are convexly arched inwards, thus coming into close contact with the assimilatory tissue. The lateral walls are thin and undulated. The stomata are more numerous on the lower surface and are raccompanied by ordinary epidermal cells. Guard-cells are situated in the plane of the outer epidermal walls; and the front cavity is on a level with the surface.

The hairy covering consists of clothing and glandular hairs; the former are more numerous on the lower surface and the latter more numerous on the upper. The clothing hairs are unicellular and have muriculate walls; the basal portion is conical and is inserted between the epidermal cells (figs. 79, 81). Glandular hairs are formed of a short uriseriate stalk and of an obconical head (figs. 79, 80).

The mesophyll is composed of a layer of very long palisade cells on the adaxial side and of an arm-palisade tissue on the abaxial side. The elongated form of the palisade cells affords protection, against intense light, to the chlorophyll grains. The greatly elongated palisade cells, the development of arm-palisade tissue and the thickening of the outer and inner epidermal walls are distinct proofs of xerophytic characters developed by the plant. Internal secretory organs are not found in the leaf or axis. Oxalate of lime occurs in the form of clustered crystals near the veins.

The leaves are many-ribbed. The ribs are prominent below and grooved above. The veins of the ribs are vertically transcurrent above by colourless parenchyma and below by collenchyma. Smaller veins are embedded. Bundle-sheaths are not found round the veins

SIMARUBACEAE.

Balanites Roxburghii *Planch.*—Figs. 82. 83, 84. Epidermal cells of the leaf and axis tabular. Mesophyll bifacial. Stomata depressed with guard-cells below the plane of the sorrounding cells. Internal glands absent. Oxalate of lime found in the form of solitary and clustered crystals in the leaf and axis. Veins embedded and enclosed in bundle sheaths. Groups of water-storing tracheids occurring at intervals between the veins. Clothing hairs present in the form of short thick-walled unicellular trichomes. Glandular hairs absent. Assimilatory tissue in the axis formed of chlorenchyma. Cortical

parenchyma with numerous water-storing tracheids. Pericycle formed of small groups of stone-cells. Vessels small and few. Interfascicular wood prosenchyma extensive. Medullary rays 1-2 seriate Xylem bundles occurring in the soft bast. Pith characterised by sieve-sclereids.

Structure of the Leaf.—The epidermal cells are tabular with outer and inner walls convexly arched outwards and inwards respectively. The outer walls are thickened. The cuticle is striated. The lateral walls are thin and straight. The stomata are depressed and are more numerous on the lower surface and are surrounded by ordinary epidermal cells. Guard-cells are situated in a plane a little below that of the surrounding cells (figs. 82, 84).

The mesophyll is composed of palisade tissue on the upper side and of spongy on the lower. Internal glands do not occur in the leaf and axis. Oxalate of lime occurs in the leaf in the form of solitary crystals and clustered crystals near the veins of the leaf and in the cortical parenchyma of the axis. The veins are embedded and are provided with green bundle-sheaths; they are protected on the lower side by sclerenchyma. There are numerous groups of water-storing tracheids with pitted markings, occurring at intervals between the veins.

The hairy covering on the leaf and axis consists of thick-walled unicellular straight or bent trichomes (figs. 82, 84.) External glands do not occur on the leaf and axis.

Structure of the Axis.—Epidermis consists of small vertically tabular cells with outer walls greatly thickened and convexly arched outwards. Cuticle is striated. The cortex is composed of arm-palisade tissue on its outer side and of colourless cortical parenchyma on the inner. The cortical parenchyma is distinguished by the presence of sclereids with concentric stratification and radial lamellae.

The pericycle is composed of small groups of stone-cells. The wood forms a composite hollow cylinder. The vessels are small and are arranged in incomplete rows. The interfascicular wood prosenchyma is extensive and is composed of thick-walled cells with small lumina. The medullary rays are 1-2 seriate. A few xylem bundles occur in the soft bast (fig. 83) and form an anomolous structure in the axis.

The pith is characterised by sieve sclereids (fig. 83) and is composed of thick-walled cells.

BURSERACEAE.

Commiphora Mukul *Engl.*—Plate XI, Fig. 85. Epidermal cells of the leaves with innerwalls gelatinised. Stomata present on

both the surfaces. Guard cells elevated. Mesophyll composed of palisade tissue on the upper side and of arm-palisade tissue on the lower. Balsam canals found in the phloem of larger veins and in the soft bast of the axis. Pith cells with tanniniferous contents. Oxalate of lime occurring in the form of solitary, clustered and conglomerate crystals. Larger veins vertically transcurrent below by collenchyma. Hairy covering consisting of a few uniseriate trichomes. Cork subepidermal. Assimilatory tissue in the axis formed of chlorenchyma. Vessels large and few. Medullary rays uniseriate and numerous. Sclerenchyma enclosing the lower ends of the xylem bundles. Xylem bundles found in the soft bast. Pith characterised by numerous sieve-sclereids.

Structure of the Leaf.—The epidermal cells are horizontally tabular with inner walls gelatinised and outer walls flat and thickened. They are secondarily divided by thin cross walls beneath which a mucilaginous mass is found. The lateral walls are thin and straight. The stomata are surrounded by ordinary epidermal cells and are more numerous on the lower surface. The guard-cells are elevated and the front cavity is on a level with the surface.

The mesophyll is composed of palisade tissue on the upper side and of arm-palisade tissue on the lower. Some of the palisade cells possess little chlorophyll and break down into cavities in dried material. Small scattered groups of sclerenchyma occur below the lower epidermis.

The internal secretory organs are represented by balsam canals in the phloem of the larger veins and in the soft bast in the axis (fig. 85 B.C.) There are numerous pith cells with tanniniferous contents. Oxalate of lime occurs in the form of solitary crystals near the veins. In the axis solitary as well as clustered and conglomerate crystals are found in cortical parenchyma. The hairy covering consists of a few uniseriate trichomes. External glands do not occur on the leaf and axis.

Structure of the Axis.—The epidermis consists of small tabular cells with outer walls thickened and with lateral walls thin and undulated. The cortex is composed on the outer side of cork and on the inner side of chlorenchyma.

The sclerenchymatous pericycle is not developed. The wood is composite. Vessels are few, large and arranged in incomplete rows. The interfascicular wood prosenchyma is extensive and is formed of cells with thin walls and large lumina. Small groups of sclerenchyma enclose the lower ends of the xylem bundles. The medullary rays are uniseriate and numerous. There are numerous xylem bundles in the soft bast ring giving rise to slightly ribbed appearance to the

axis. The pith is composed of thick-walled cells and is characterised by sieve-sclereids.

CELASTRACEAE.

Gymnosporia montana *Benth.*—Figs. 86, 87. Upper epidermis locally two-layered. Lower epidermis formed of vertically elongated and papillose cells. Mesophyll consisting of palisade tissue on the adaxial side and of arm-palisade tissue on the abaxial side. Internal glands consisting of cells with tanniniferous contents in the leaf and axis. Oxalate of lime not occurring in any form. Veins vertically transcurrent and enclosed in bundle-sheaths. Hairy covering absent. Pericycle composed of groups of stone-cells. Cork subepidermal. Wood prosenchyma formed of cells with thick walls and small lumina. Medullary rays 1-2 seriate. Pith heterogenous.

Structure of the Leaf.—The upper epidermis consists of tabular cells, with inner walls convexly arched inwards; it is locally two-layered by division walls which may be thin or thickened and which are parallel to the surface of the leaf. The lower epidermis consists of polygonal cells which are greatly elongated vertically and are drawn out into papillae (fig. 86). Outer walls are thickened; inner walls are also thickened except in some cases, when the upper epidermal cells are divided by walls parallel to the surface. The lateral walls are thin and straight. The tendency to form a two-layered epidermis as well as the palisade-like elongation of the epidermal cells are adaptations to protect the palisade tissue against insolation as well as to check transpiration by depressing the stomata.

The stomata are numerous only on the lower surface and are surrounded by ordinary epidermal cells. The guard-cells are depressed and the front cavity is placed in a deep depression formed by the palisade-like surrounding cells.

The mesophyll is composed of palisade tissue on the adaxial side and of arm-palisade tissue on the abaxial side. In the mesophyll there are numerous cells with tanniniferous contents. Secretory cells with tanniniferous contents are abundantly found in all tissues of the axis. Tanniniferous contents are found in cortical parenchyma, in cells separating the groups of stone-cells of the pericycle, in numerous cells in the soft bast and in the medullary ray cells which are opposed to the glandular cells between the pericyclic stone-cell groups. Oxalate of lime does not occur in any form in the leaf or axis.

The veins are enclosed in green bundle-sheaths and are vertically transcurrent above and below by colourless thick-walled parenchyma. There are small groups of stone-cells on the lower side of the phloem of larger veins, thus protecting it.

Clothing as well as glandular hairs do not occur on the leaf and axis. The absence of a hairy covering is compensated for partly by the palisade-like elongated epidermal cells and partly by the two-layered epidermis.

Structure of the Axis.—The epidermis consists of small tabular cells with outer walls thickened. The cortex is composed on its outer side of an extensive cork tissue and on its inner side of glandular tissue already described (fig. 87).

The pericycle is composed of closely placed large groups of stone-cells separated by secretory cells with tanniniferous contents. The wood is composite (fig. 87). Vessels are fairly large and numerous. Interfascicular wood prosenchyma is composed of thin-walled cells with small lumina. The medullary rays are 1-2 seriate and are numerous, some of their cells holding tanniniferous contents.

The pith is heterogenous and is composed of groups of large elongated cells surrounding small cells (fig. 87).

RHAMNEAE.

Zizyphus jujuba *Lam.*—Fig 88. Epidermis composed of horizontally tabular cells. Upper epidermis of the mid-rib grooved. Uniseriate trichomes more numerous on the lower surface. Secretory cavities not found in cortex. Pericycle formed of stone-cells. Long thin groups of stone-cells present in soft bast.

Zizyphus trinervia *Roxb.*—Figs. 89, 90. Epidermis of the leaf composed of cubical or vertically tabular cells. Upper epidermis of the mid-rib not grooved. Uniseriate trichomes absent on the upper surface. Secretory cavities numerous in the cortex. Long thin groups of stone-cells found in soft bast. Pericycle formed of bast fibres.

Zizyphus rotundifolia *Lam.*— Figs. 91, 92. Epidermis of the leaf formed of cubical and vertically tabular cells. Upper epidermis of the mid-rib grooved. Uniseriate trichomes more numerous on the lower epidermis. Secretory cavities wanting in cortex. Stone-cells absent in soft bast. Pericycle formed of bast fibres.

Zizyphus truncata *Blatt. and Hall.*—Figs. 93, 94. Upper epidermis consisting of cubical and vertically tabular cells. Upper epidermis of the mid-rib not grooved. Uniseriate trichomes absent on the upper surface. Secretory cavities occurring in cortex. Stone-cells wanting in soft bast. Pericycle formed of bast fibres.

Structure of the Leaf:—The epidermis of the two surfaces differ in structure. The upper surface is smooth while the lower one is characterised by alternate ridges and furrows. The epidermal cells of the upper surface are larger and cubical or vertically tabular in all members (figs. 91, 93,) except *Z. jujuba* where they are mostly

horizontally tabular (fig. 88.) The outer walls are thickened and the lateral walls are thin and straight. The inner walls are thin and convexly arched inwards, so as to come into close contact with the assimilatory cells. Some of the upper epidermal cells are filled with yellowish brown contents of the nature of cellulose slime. The epidermal cells of the lower surface are smaller and are horizontally tabular, the outer walls being thickened and the inner and lateral walls thin.

Stomata occur only on the lower surface and are mostly found on the ridges. Guard-cells are situated in the plane of surrounding cells and the front cavity is on a level with the surface.

The mesophyll is composed wholly of palisade cells which are more compact towards the upper surface and are somewhat loosely arranged towards the lower, especially so below the ridged where the stomata are mostly situated (fig. 93.) There are groups of palisade-like cells with faintly yellowish contents, usually above the veins. These perhaps function as water reservoirs. Cells with clustered crystals are numerous near the veins.

Internal glands are represented by groups of palisade-like cells on the upper side of the veins and by rounded cells near the veins, with faintly yellowish contents and functioning perhaps as water-storing tissue. Some of the upper epidermal cells hold faintly yellowish contents of the nature of the cellulose slime.

Secretory receptacles of lysigenous origin occur in the pith of all members and in the inner portion of primary cortex of *Z. trinervia* and *Z. truncata*. The secretory receptacles, as presented in T. S., are numerous and elongated in the former and rounded and few in the latter. The contents seem to be mucilaginous. The secretory receptacles in the pith are large and are lined by a layer of flattened cells resembling an epithelium. Some of the pith cells contain tannin.

Oxalate of lime occurs in the form of numerous clustered crystals in the neighbourhood of the veins.

The veins are embedded and have no distinct bundle-sheaths. There are numerous groups of water-storing tracheids at the terminations of the veins (fig. 93.) The veins of the mid-rib are vertically transcurrent above and below by collenchyma. The mid-rib is prominent below in all species; it is grooved on the upper surface in *Z. jujuba* and *Z. rotundifolia*; in the other species it is not grooved, the upper epidermis being composed of vertically elongated cells with inner and lateral walls thickened.

The epidermal cells of the lower side of the mid-rib and of the upper side, when it is not grooved, are small polygonal cells slight-

ly thickened on all sides, thus adding to the rigidity of collenchyma above and below the veins of the mid-rib.

The hairy covering is composed of uniseriate trichomes (figs. 88, 93.) These are more numerous on the lower surface in *Z. jujuba* and *Z. rotundifolia.* In the other members they seem to occur on the upper surface only. Hairy covering on the axis consists of a few uniseriate trichomes as on the leaf. External glands are not found on leaf or axis.

Structure of the Axis :—The epidermis consists of small polygonal cells thickened on all sides. The primary cortex is characterised by the extensive development of subepidermal cork and by mucilaginous secretory cavities in *Z. trinevia* and *Z. truncata.*

The pericycle is composed of a composite and continous ring of bast fibres in all species except *Z. jujuba,* where it is represented by a composite and continuous ring of stone-cells. There are found long thin groups of stone-cells in the soft bast of *Z. jujuba* and *Z. trinervia.*

The wood forms a composite hollow cylinder in all species. The vessels are large having simple perforations and are arranged almost in complete rows. The interfascicular wood prosenchyma is extensive and is composed of cells with thick walls and small lumina The medullary rays are uniseriate and numerous.

The pith consists of thick-walled cells and is characterised by large mucilaginous secretory cavities. Some of the pith cells hold tanniniferous contents.

General Review :—The species of *Zizyphus* have the same structure in the leaf and axis with certain differences which may be useful in the diagnosis of the species :—

1. Presence or absence of uniseriate trichomes on the upper surface of the leaf.
2. Shape of the upper epidermal cells.
3. Presence or absence of a groove on the upper epidermis of the mid-rib.
4. Pericycle formed of bast fibres or of stone-cells.
5. Presence or absence of stone-cells in soft bast.

SAPINDACEAE

Cardiospermum Halicacabum *L.*—Fig. 95. Epidermal cells tabular with inner walls gelatinised. Stomata occurring on both the surfaces. Mesophyll formed of palisade tissue on the adaxial side and of arm-palisade tissue on the abaxial side. Cells with tanniniferous contents in soft bast and pith. Oxalate of lime found in the leaf and axis. Leaf many-ribbed. Veins vertically transcurrent Clothing hairs unicellular or uniseriate. Glandular hairs formed of

a short uniseriate stalk and of an ovoid curved head. Pericycle formed of a composite ring of stone-cells. Axis ribbed. Ribs strengthened by collenchyma. Assimilatory tissue in the axis formed of chlorenchyma. Wood formed of xylem bundles connected by strands of interfascicular wood prosenchyma. Medullary rays absent. Pith formed of thin walled cells.

Structure of the Leaf:—The epidermis consists of tabular cells which are much larger on the upper surface. The outer walls are a little thickened; the inner walls are gelatinised, and those of the upper epidermis are greatly arched convexly inwards. The lateral walls are very thin and straight. The gelatinisation of the inner walls of the epidermal cells compensates for the hairy covering which is scanty. The stomata are more numerous on the lower surface, and are surrounded by ordinary epidermal calls.

The mesophyll is composed of palisade tissue on the adaxial side and of arm-palisade tissue on the abaxial side. Internal secretory organs do not occur in the leaf. They are represented in the axis by secretory cells with tanniniferous contents in the soft bast and pith. Oxalate of lime occurs in the form of numerous clustered crystals near the veins in the leaf. The clustered crystals occur in a layer of cells outside the pericycle and in the pith of the axis.

The veins are provided with green bundle-sheaths. The leaves are many-ribbed and the veins of the ribs, which are prominent below, are vertically transcurrent above and below by collenchyma. The smaller veins are embedded.

The hairy covering consists of clothing and glandular hairs. The clothing hairs on the leaf are short, thick-walled, unicellular and with a sharp point. The clothing hairs on the axis are longer with muriculate walls; the basal portion is divided by two to three cross-walls. The glandular hairs are formed of a short uniseriate stalk and of a small ovoid head which is curved and is divided by horizontal walls (fig. 95).

Structure of the Axis :—The axis is ribbed. The epidermal cells are small and vertically tabular with outer walls greatly thickened and convexly arched outwards. The primary cortex is formed of chlorenchyma which is bounded internally by a layer of thin-walled colourless cells mostly containing clustered crystals. Strands of collenchyma are developed in the ribs.

The pericycle is formed of a composite ring of stone-cells. The wood is composed of xylem bundles connected together by narrow strands of interfascicular wood prosenchyma formed of cells having thin walls and large lumina. The vessels are very large and have simple perforations. Medullary rays are absent.

The pith consists of thin-walled cells.

MORINGASEAE

Moringa pterygosperma *Gaert.*—Figs. 96, 97. Leaf. Water-storing cells vertically elongated, conspicuous and numerous in upper epidermis. Mesophyll formed of palisade tissue on the adaxial side and of spongy tissue on the abaxial side. Myrosin cells in the form of palisade-like cells and confined to the palisade tissue. Oxalate of lime absent. Veins enclosed in bundle-sheaths. Short unicellular clothing hairs occurring on both surfaces.

Moringa concanensis *Nimmo.*—Fig, 98. *Leaf.* Water-storing cells in upper epidermis few and formed of a little enlarged epidermal cells. Lower epidermal cells with outer walls forming large papillae. Mesophyll composed of rows of palisade cells separated by myrosin cells on the adaxial side, and of armpalisade tissue on the abaxial side. Myrosin cells occurring between the rows of palisade cells as well as on the inner side of arm-palisade tissue. Clustered crystals of oxalate of lime numerous near veins and below lower epidermis. Veins not enclosed in bundle-sheaths but strengthened by arcs of stone-cells on their lower side. Hairs absent.

Structure of the Leaf:—The epidermis differs in structure on the two surfaces. The epidermal cells on the upper surface are tabular with outer and inner walls equally thickened and convexly arched outwards and inwards respectively. There are large water-storing cells, which are numerous and conspicuous in *M. pterygosperma* (fig. 96) intercalated amongst the ordinary epidermal cells, (figs. 96, 98). The epidermal cells on the lower surface are much smaller than those on the upper surface. The outer and inner walls are equally thickened and the latter are curved convexly outwards in the form of papillae which are very large in *M. concanensis* (fig. 96). Lateral walls are thin and straight.

Stomata occur only on the lower surface and are surrounded by ordinary epidermal cells. Guard-cells are situated quite below the plane of the epidermal cells. The front cavity is therefore placed in a pit as deep as the height of the epidermal cells; air in these pits remains moist and transpiration is thus greatly diminished. This kind of contrivance is necessary in leaflets of species of *Moringa* which are not protected by a dense covering of hairs and which, on the other hand, are greatly shaken by wind, thus accelerating transpiration.

The hairy covering consists of a few short, thick-walled unicellular clothing hairs found on both the surfaces of *M. pterygosperma* (fig. 96); it does not occur in *M. concanensis*. External glands are absent.

The mesophyll differs in structure in the two species. In *M. pterygosperma* (fig. 96) it is composed of palisade tissue on the adaxial side and of spongy tissue on the abaxial side. In *M. concanensis* (fig. 98) the palisade tissue occurs on the upper side and is composed of rows of palisade cells separated by greatly elongated myrosin cells; a single layer of arm-palisade cells occurs below the lower epidermis.

Internal secretory organs are abundantly developed, in the mesophyll of *M. concanensis* (fig. 98G.) They are partly composed of greatly elongated tabular cells between the rows of palisade cells and partly of horizontally elongated polygonal cells forming a more or less continuous layer on the inner side of the arm-palisade tissue. Secretory cells in *M. pterygosperma* (fig. 96G) are abundant in the palisade tissue and are repersented by palisade-like cells. Internal secretory cells hold yellowish brown contents and seem to be of the nature of myrosin cells.

Oxalate of lime occurs in the form of numerous clustered crystals near the veins and below the lower epidermis of *M. concanensis*. It is not found in *M. pterygosperma*.

Veins are embedded in both the species. They are enclosed in green bundle-sheaths in *M. pterygosperma*; they are strengthened by arcs of stone-cells on their lower side in *M. concanensis*.

PAPILLIONACEAE

Heylandia latebrosa *DC.*—Fig. 99. Epidermal cells polygonal. Large water-storing cells intercalated amongst ordinary epidermal cells. Mesophyll bifacial. Veins vertically transcurrent by sclerenchyma. Tannin sacs absent. Clothing hairs in the form of uniseriate trichomes with muriculate walls. External glands absent. Assimilatory tissue in the axis chlorenchymatous. Pericycle formed of bast fibres. Medullary rays uniseriate. Pith formed of thin-walled cells.

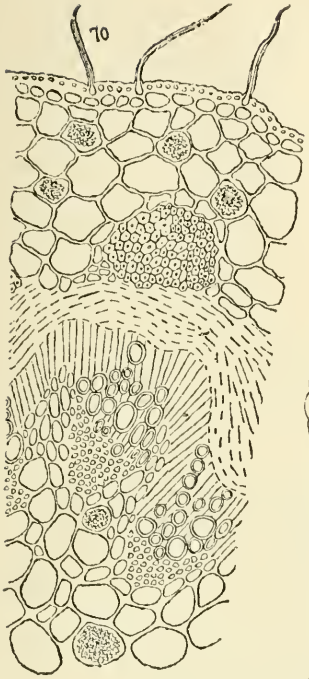
Crotalaria Burhia *Ham.*—Figs. 100, 101. Epidermal cells polygonal with lateral walls undulated. Large water-storing cells intercalated amongst ordinary epidermal cells. Mesophyll isobilateral. Veins embedded and enclosed in bundlesheaths. Tannin sacs found near the veins. Clothing hairs in the form of uniseriate trichomes with muriculate walls. External glands absent. Assimilatory tissue in the axis formed of palisade cells. Pericycle formed of stone-cells. Medullary rays uniseriate. Pith formed of thin-walled cells. Cortical vascular bundles present.

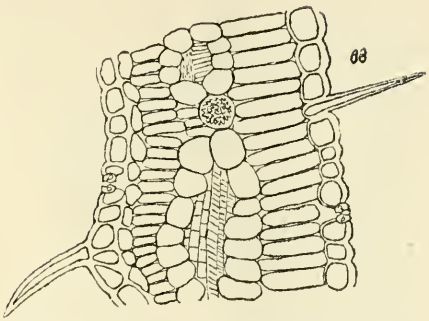
(*To be continued.*)

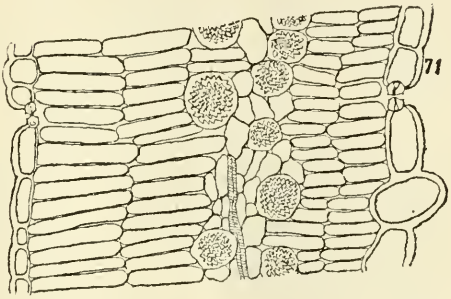
Plate IX

68-70. *Tribulus terrestris.*
68. T. S. of the leaf.
Oc. 1 ; Ob. 3 mm. Ap.
69. Hair on the leaf.
Oc. 1 ; Ob. 3 mm. Ap.
70. T. S. of the axis.
Oc. 3 ; Ob. C.
71-74. *Sectzenia orientalis.*
71. T. S. of the leaf.
Oc. 1 ; Ob. 3 mm. Ap.
72. Stoma on the leaf.
Oc. 4 ; Ob. 3 mm. Ap.
73. T. S. of the axis.
Oc. 4 ; Ob. C.
74.
75. *Zygophyllum simplex.*
T. S. of the leaf.
Oc. 3 ; Ob. A.

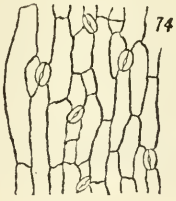
N.B.—To get the original dimensions multiply by 1·7.

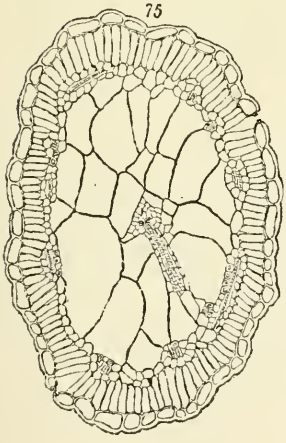


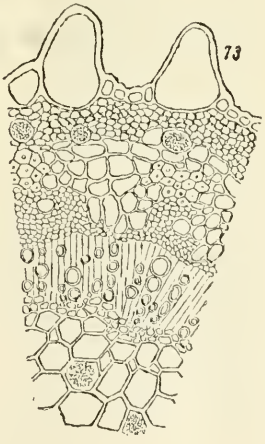


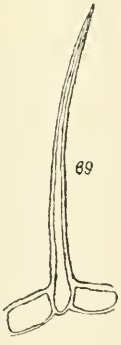












T. S. Sabnis del.

PLATE IX.

Plate X

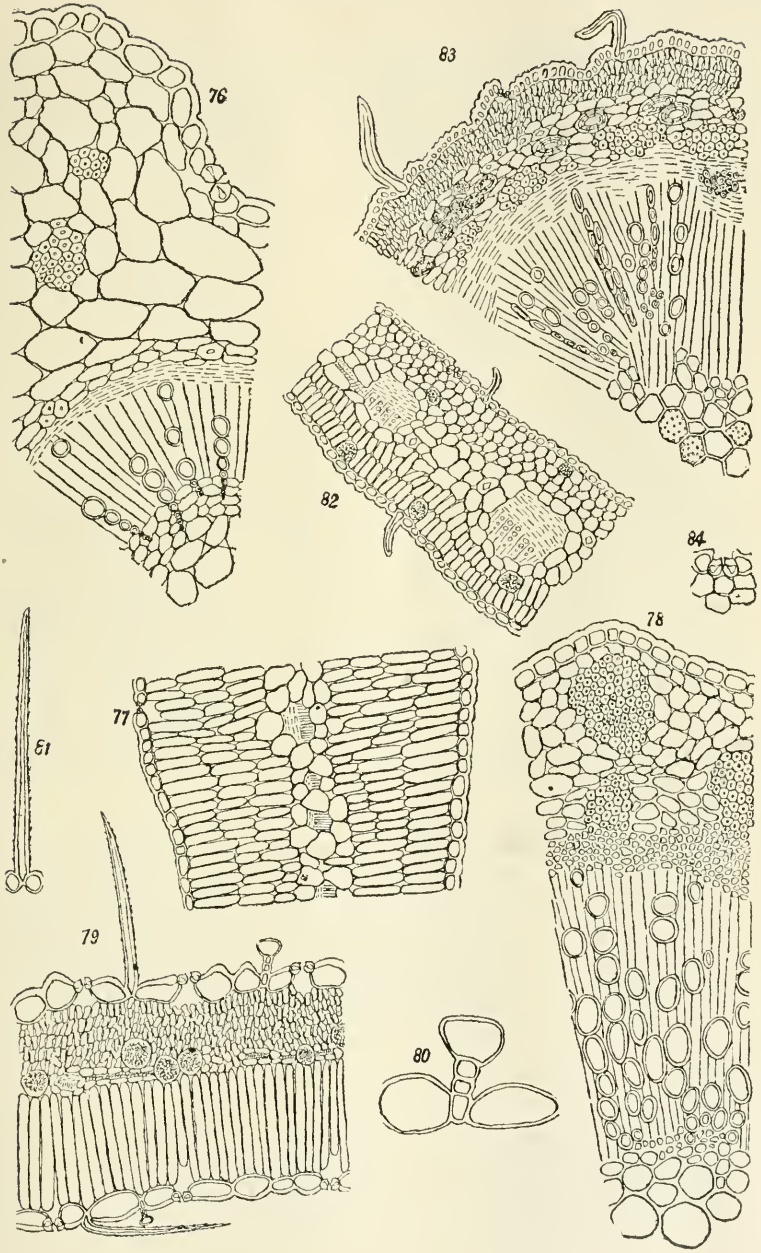
76. *Zygophyllum simplex.*
T. S. of the axis.
Oc. 1 ; Ob. 3 mm. Ap.

77-78. *Fagonia cretica.*
77. T. S of the leaf.
Oc. 2 ; Ob. C.
78. T. S. of the axis.
Oc. 3 ; Ob. C.

79-81. *Monsonia heliotropioides.*
79. T. S. of the leaf.
Oc. 6 Com. : Ob. 8 mm. Ap.
80. Glandular hair on the leaf
Oc. 6 Com. ; Ob. 3 mm. Ap.
81. Hair on the leaf.
Oc. 2 Com. : Ob. 3 mm. Ap.

82-84. *Balanites Roxburghii.*
82. T. S. of the leaf.
Oc. 6 Com. ; Ob. 8 mm. Ap.
83. T. S. of the axis.
Oc. 6 Com. ; Ob. 8mm. Ap.
84. Stoma on the leaf.
Oc. 6 Com. ; Ob. 3 mm. Ap.

N.B.—To get the original dimensions multiply by 1·7.



T. S. Sabnis del. PLATE X.

Plate XI

85. *Commiphora Mukul.*
T. S. of the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.

86-87. *Gymnosporia montana.*
86. T. S. of the leaf.
Oc. 6 Com.: Ob. 8 mm. Ap.
87. T. S. of the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.

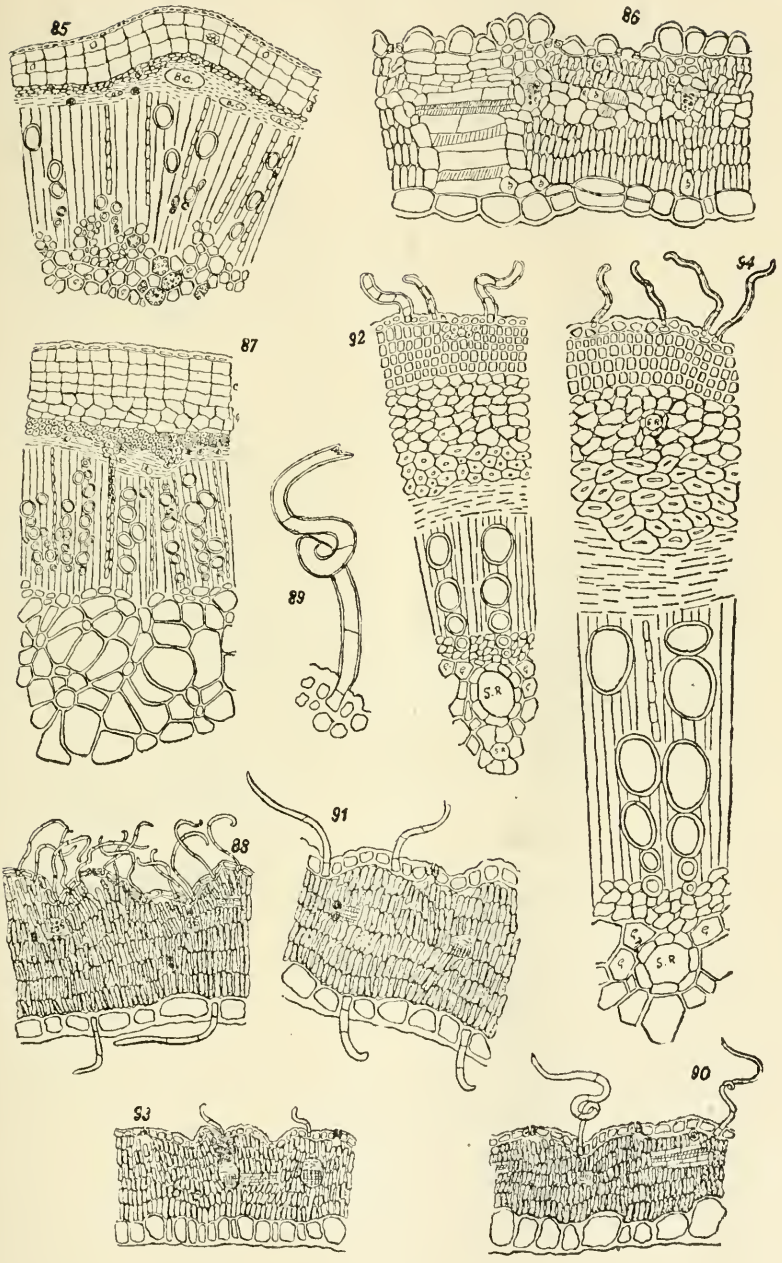
88. *Zizyphus jujuba.*
T. S. of the leaf.
Oc. 3; Ob. C.

89-90. *Zizyphus trinervia.*
89. Hair on the leaf.
Oc. 3; Ob. 7
90 T. S. of the leaf.
Oc. 3; Ob. C.

91-92. *Zizyphus rotundifolia.*
91. T. S. of the leaf.
Oc. 3; Ob. C.
92. T. S of the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.

93-94. *Zizyphus truncata.*
93. T. S. of the leaf.
Oc. 1; Ob. C.
94. T. S. of the axis
Oc. 4 Com.; Ob. 3 mm. Ap.

N.B.—To get the original dimensions multiply by 1·7.



T. S. Sabnis del.

PLATE XI.

Plate XII

95. *Cardiospermum Halicacabum.*
T. S. of the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.

96-97 *Moringa pterygoeperma.*
96. T. S. of the ieaf.
Oc. 6 Com.: Ob. 8 mm, Ap.
97. Stoma on the leaf.
Oc. 6 Com.; Ob, 3 mm. Ap

98. *Moringa concanensis.*
T. S. of the leaf.
Oc. 6 Com.; Ob. 8 mm. Ap.

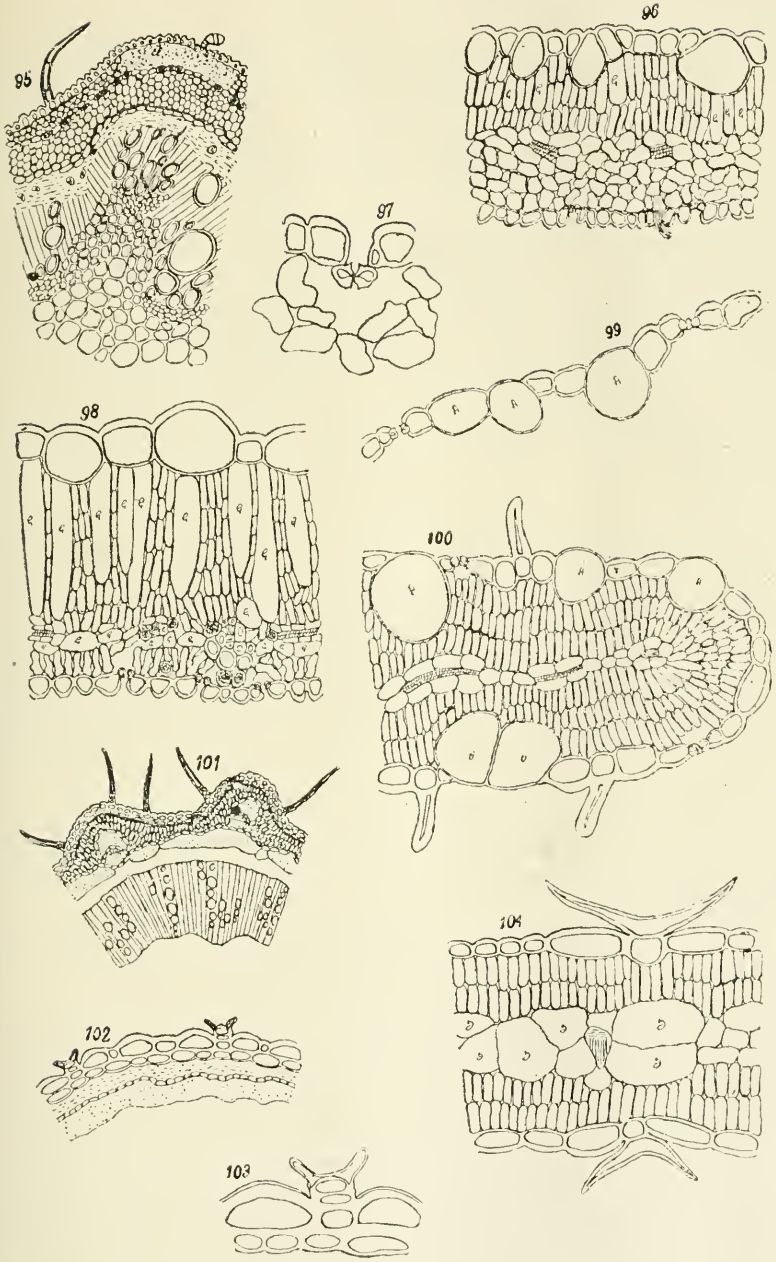
99. *Heylandia latebrosa.*
T. S. of the leaf showing epidermis.
Oc. 6 Com.: Ob. 8 mm. Ap.

100-101. *Crotalaria Burhia.*
100 T. S. of the leaf.
Oc. 6 Com.: Ob. 8 mm. Ap.
101 T. S. of the axis.
Oc. 2 com,; Ob. 8 mm. Ap.

102-103 *Crolalaria medicaginea.*
102. T. S. of the axis.
Oc. 6 Com.; Ob. 8 mm. Ap.
103. Hair on the axis.
Oc. 6 Com.; Ob. 3 mm. Ap.

104. *Indigofera cordifolia.*
T. S. of the leaf.
Oc. 4 Com.; Ob. 3 mm. Ap.

N.B.—To get the original dimensions multiply by 1·7.



T. S. Sabnis del. PLATE XII.

SUSPECTED PARASITISM IN A MOSS.

BY

T. Ekambaram, M.A., L.T.

Presidency College, Madras.

The Mosses, though of very common occurrence and of wide distribution, have received little attention from the botanist as regards their physiology of nutrition. In the eighties, there were two opinions about the function of rhizoids in mosses. In 1886, Vaizy [1] showed experimentally that there was no transpiration current in the stem of a moss because no eosin rose into the stem when the cut end was dipped in a solution. Vaizy held that all water absorption was done by the leaves. Later, Haberlandt [2] wrote that, a study of rhizoids in mosses and a consideration of their abundance and extensive branching in the soil, had led him to believe that their function was not merely fixation but was also absorptive, A different aspect of the function of rhizoids is met with in saprophytic mosses, though only very few thorough saprophytes with colourless aerial portions are known. The others have a green aerial portion but their rhizoids penetrate into dead organic substratum. The rhizoids in these are described as being minutely sub-divided and as having the appearance of fungal hyphae with H shaped connections or netted masses.

Observations made by the author on a species of moss, common in Madras, may be of interest, as they show that the rhizoids are, in the early stages, parasitic on colonies of algae, a habit not hitherto suspected in mosses.

The moss grows on walls coated with lime and exposed to the rains during the monsoon weather. Before the rains, the wall has a debris of old dried up mosses on it. After the rains in two or three days, the dried up stumps put forth a few leaves by the growth of the dormant buds at their tips and small green plants dot the surface of the wall. New rhizoids develop immediately below the cluster of leaves and fresh buds are formed in between the plants from the old rhizoids which contain food material stored in them. At the same time, this portion of the wall and also fresh areas surrounding it get coated with a dirty green colour due to the growth

[1] Vaizy, J. Reynolds: *Ann. of Bot. Vol. 1*; *p. 148.*

[2] Haberlandt; *Physiolcgical Plant Anatomy*: *Enq. Ed. 1914, pp. 226—230, 725.*

of blue-green algae. The algae commonly found in these situations, are colonies of Nostoc embedded in soft mucilage, colonies of another blue-green with tough mucilage and filaments of Scytonema. Under the microscope, these appear as masses of algal cells or filaments. The rhizoids of the young plants enter into the algal masses and come into intimate contact with them. In a few more days, the young plants produce a great number of gemmae from the axils of the leaves near the tip of the stem. These get detached and are distributed beyond the area of the wall originally covered by mosses, and get mixed up with the algae growing in these regions. In the outskirts of the older patches, the rhizoids of the young plants grow into the new substratum and give rise to protonema filaments which are covered by masses of blue green algae. Gradually new moss plants appear in these regions and the spreading of the moss on the wall continues. It is a matter of constant observation that no new plants develop in regions of the wall where the algae have not already appeared.

Protonemal Stage.—A microscopic examination of the outskirts of the moss patches, where to all outward appearance no moss plants but only algae are found, show masses of protenema filaments or germinating gemmae. The protenema filaments arise from rhizoids of young plants further up or from hibernating rhizoids of the previous season which had extended so far. The protonemal filaments branch frequently and are mixed up with algal masses and soil particles.

In the preparation of slides, the lime substratum was dissolved with dilute HCl and the sand particles left behind were removed by careful teasing with fine pointed needles. The material for mounting, both in the case of protonema and also in the case of rhizoids of the moss plants in different stages, was prepared in this way, stained and mounted in glycerine.

The greater part of the protonema branches were bright green in colour with prominent chloroplasts. But the tips of the filaments in many cases and some of the branches gradually became colourless and finely branched. (Fig. 2.) This colourless portion was always in intimate contact with the algal masses. During teasing, it was often noticed that the green portion was easily detached from the algal masses but they always had their ends broken. Light crushing of the algal mass and differential staining showed that the colourless tips of the protonemal filaments extended into the gelatinous masses of algae and there spread in between the algal cells. In some, where the algae form soft gelatinous masses, the branches had short beaded cells which occupied the centre of the mass. In others, where the algae had tough

mucilage and formed smaller colonies or where they were filamentous, the protonema branches became long and filamentous with long or short cells, and surrounded or intertwined with the algae. During examination of the slides, one is often reminded of the condition in Lichens, with the fungus filaments coiling round big algal cells. This condition is much more striking in the case of the rhizoidal branches of the young moss plants. In the protonemal masses, the similarity is brought out especially, where the cells in contact with the algae are beaded and short as in some lichens. In the mass of algae in the vicinity of the branches, it is common to meet with both decaying and healthy algal cells and those which have partly or fully lost their cell-contents.

Germinating Gemmae.—The Gemmae, when detached from the plant, are club-shaped and 3 or 4 cells long. The first sign of germination is the putting forth of a rhizoidal cell from the basal end. This is followed or in some cases preceded by an oblique division of the apical cell. The rhizoidal cell grows quickly into a filament and extends into the algal masses, in the same manner as that described for the protonema branches though not to the same extent in the early stages. (Fig. 2.)

The Young Moss Plant.—In the young moss plants, when the mud attached to the rhizoids is carefully washed out, it is found that the main rhizoids have dark clots hanging from their ends. These clots, when repeatedly crushed lightly under the cover slip and washed or when treated with dilute HCl, show masses of algae attached to the tips of the main rhizoidal branches. (Fig. 1.) The algae are again of all the three kinds mentioned above, namely, big soft jellies, tough small colonies, and long filaments. These three are the predominant forms, though other forms occur more rarely. The rhizoids on entering the algal masses behave very much in the same way as the tips of protonema branches. In many cases, a much more extensive and minute branching takes place and the resemblance to fungal hyphae coiling round algal cells in Lichens, is very striking. H like connections and net-work formations are more common. In favourable preparations, the encircling of the algal colonies by rhizoidal branches is clearly seen.

Fig. 6 shows a few Nostoc colonies attached to the rhizoidal branches. Fig. 5 shows one of the colonies lightly crushed under the cover glass. The penetration of the branches into the alagal colony is seen. Further examination shows an extremely minute sub-division of the rhizoidal branches and their extension in between the cells of the colonies. In case of colonies with small algal cells, it was not possible to follow the finer ramifications and see exactly in what



M. V. Rangam del.

way the algal cells were attacked by the rhizoidal branches. But usually, either mixed up with the small cells of the colonies or independently, bigger cells of a different species of alga are met with. A few such are shown in Figs. 3 and 4 with the rhizoidal branches, which here consist of short cells, surrounding the algal cells and closely adpressed to them.

But even in these cases no special structures of absorption such as haustoria have been noticed. That haustoria are not a necessary condition for parasitic or symbiotic relationship is shown in the cases of many fungi and also lichens.

The effect of the intimate contact with the algal colonies is seen very clearly. At the beginning, the algal cells are full of protoplasm with bright blue-green colour and have a healthy vigorous appearance. But gradually the colour fades and the contents disappear. Some of the cells of a colony remain vigorous and healthy whereas others are completely or partly decayed. Scytonema filaments, with the portions in contact with the rhizoidal branches in a decaying condition, are quite common. At still later stages, the individual cells of the colonies are not recognisable and only a debris of cell-walls is left. In the case of Scytonema, the thick sheaths devoid of their contents are often met with surrounding the rhizoidal branches.

In plants, which had not been growing for more than a fortnight, large quantities of food material are often found stored up in the rhizoids whose minor branches penetrate into the algal masses. And it is not uncommon to find some of the branches inside the algal masses swollen and full of food material. It is evident that the plants themselves could not have manufactured all this food material by the activity of its green parts, within such a short time and it gives room to a very strong presumption for an external source of the food material. The extraordinary minute branching of the rhizoids, and the intimate contact of the branches with the algal colonies which resembles the behaviour of the fungal hyphae occurring between the algal cells in the Lichens, further strengthens the presumption, that the relation between the moss rhizoids and the algae, is very likely to be one of parasitism of the rhizoids on the algal colonies. My friend Mr. M. O. Parthasarathy Iyengar corraborates my observation and says that in his wanderings in search of algae he had repeatedly noticed that the young moss plants invariably appear only on substrata which are first covered over with blue green algae. He is inclined to believe that the same thing holds good for the common Liverworts which appear immediately after the monsoon in Madras.

As the mosses grow taller, the algae on the substratum disappear

and in the older mosses no algae are found in contact with rhizoids. But it is at the same time interesting to note that the rhizoidal system is also very much reduced in extent by the death of the finer branches. In these, there is a lot of food material found stored in the bigger rhizoidal branches and most of the finer branches are shrivelled up and non-functional. Here and there, a few algal masses are met with on the plants at the axils of the leaves where some dirt has accumilated and into those also rhizoids from the cortical cells of the stem penetrate. But on the whole, in the older plants the amount of algae in their vicinity is very little when compared with the younger plants.

The absence of the algae in the later stages of the life of the moss plant may be accounted for by the fact that the conditions near the substratum are no longer favourable to the growth of algae. The moss plants grow very close to each other and to nearly the height of an inch, so that there is very little light available near the substratum. Higher up on the plants themselves the moisture conditions are not favourable except in special situations. But where they occur, rhizoids penetrate them.

The above observations lead the author to believe that the common moss in Madras is parasitic on the blue green algae of the substratum, when the moss plant is young and also in the protonema stage.

Explanation of Figures on page 209

Fig. 1. Moss plant with algal masses attached to the rhizoids.
Fig. 2. Mass of protonema filaments, some with and some without chloroplasts; ends of filaments broken. One germinating gemma also shown.
Fig. 3. Rhizoidal branch encircling an algal colony.
Fig. 4. Rhizoidal branch with short cells encircling algal cells.
Fig. 5. Nostoc colony crushed showing main rhizoidal branches inside.
Fig. 6. Rhizoidal branches entering Nostoc colonies.

VARIATION IN BOMBAY *STRIGAS.*

BY

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The present paper is a preliminary note embodying scattered observations on variation in species of *Striga* found in the Bombay Presidency.

In the course of the writer's investigation of the flora of Indian grasslands he frequently found *Striga* species. Many of these seemed to be imperfectly described in floras. A closer study of these species was therefore made. It will be convenient to take these one by one.

I. S. lutea: A species of wide geographical distribution, given in the floras of Hooker and Cook for India, Trimen for Ceylon, and Mueschler for Egypt. Pearson mentions its occurrence in South Africa where it is a serious pest on maize. In the Bombay Presidency it is a pest of jowar (*Andropogon Sorghum*) and bajri (*Pennisetum typhoideum*).

A. In these floras, in the species keys and descriptions the number of calyx ribs of the species is given as follows:

Hooker: Key, 10-15; Description, 10-ribbed, rarely 15-ribbed.

Cook: Key, 10-15 ribbed, ribs of the calyx most commonly 10; Description "Calyx . . . with one strong hirsute rib running from the base of the calyx to the apex of each tooth, and with 1 (less commonly 2) secondary ribs between them, which terminate at the sinus."

Trimen: Key and description, 10.

Mueschler: Key 10-17 ribbed; 10 ribbed; Description, generally 10 ribbed.

Van Buuren, a graduate of the Poona College of Agriculture, and now in the Ceylon Department of Agriculture, in his paper [1] on Root Parasitism in Some Scrophulariaceae of Western India, states that *S. lutea* is usually 10 to 12 ribbed.

The above descriptions would seem to indicate a certain amount of variation in the number of calyx ribs, and the writer has found this to be the case in even the small number of specimens studied by him personally. 11 ribs are common. One plant gave flowers having respectively 11, 14, and 13 ribs. Another gave 11 and 13, and two others 14 and 13 on each plant. On one plant 15 ribs were found in

(1) Poona Agricultural College Reports No. 1.

one calyx. It is to be noted that additional ribs are never obtained by the increase of the number of main ribs but always by the intercalation of additional secondary ones. If there is only one additional secondary rib that has been always found in an anterior position (fig. 1).

The case of the 15-ribbed plant is shown in fig. 2.

10-ribbed cases were found in many plants collected from Karjat, a station on the line between Bombay and Poona, but few were found among those collected actually at Poona.

B. The colour of the corolla of *S. lutea* is given as follows :

Hooker : " Scarlet, purple, yellow or white. "

Cook : " Usually bright yellow, occasionally red or white. "

Trimen : " Bright chrome yellow. "

Mueschler : " Scarlet, red, yellow or white. "

Van Buuren, in an MS. note dated Oct. 21, 1913 says " Corolla in early stages white, becomes a light chrome yellow when older or sometimes chrome yellow."

L. J. Sedgwick, writing to me on 3-9-19 states " The fact that *S. lutea* could be any other colour than yellow had escaped my notice. . . . It is always yellow in the Dharwar Malnad and the Nilgiris." Writing to me later on 15-11-19 the same botanist says ":As regards *S. lutea*, Bell swears to having seen the red-flowered form once at Ekambi in Kanara."

The corolla colours observed by the present writer are two (1) a sulphur yellow in plants found in grassland at various places, this colour of corolla has never, up to date, been observed by the writer in plants parasitic on crops ; (2) a faintly creamy white, slightly deeper in colour at the throat, in plants parasitic on jowar, bajri, and grasses.

The writer has never seen a red or a purple. There is some probability that Hooker's purple is a description of the bluish tinge which the corolla, and in fact, the whole plant, take on very soon after being plucked.

C. The *anthers* are not described by any of the botanists whose floras have been mentioned. The anthers in *S. lutea* are brownish-yellow in both white and yellow varieties. The colour of the anthers is an aid to distinguishing the white variety from *S. densiflora*. In *S. densiflora* the anthers are bluish-black.

With reference to the yellow variety the writer would quote the following footnote from Van Buuren :

> " Since the publication of this, a specimen which is very similar to *Striga sulphurea* according to the description

given by Cooke was found in the grass lands at Alibag on the banks of a tank. It can hardly deserve rank as a new species, being apparently a small form of *S. lutea*. The corolla is of a deep yellow colour."

The present writer has never seen *S. sulphurea*. L. J. Sedgwick in a letter mentions it as a rare plant found during the monsoon in the Malnad, and says he has specimens.

H. S. densiflora: This is described in all floras as having a 5-ribbed calyx and the writer has found no exceptions to this rule. The 5 primary ribs exist and there are no secondaries.

The corolla is variable in size and shape (fig. 3). The following table gives a comparison of the tube length, anteroposterior and lateral diameters of the flowers of *S. lutea* and *S. densiflora*.

Table.

	Striga lutea.					Striga densiflora.					
	mm.									*a.*	*b*
Tube ...	12	12	10	11	13	10	10+3	10+3	8+3	10+3	7+2
Antero-posterior diameter.	10	10	6	6	10	6	8			12	6
Lateral diameter.	10	9	7	7	10	6	10			12	8

a b, These two plants were growing within a foot of each other. All flowers on one plant of uniform type.

The curve in the tube of *S. densiflora* is much more marked than in that of *S. lutea* (fig. 4.) Hence the 10+3, &c. in the tub-length measurements of the former 10 being the measurement below and 3 above the bend Van Buuren in his MS. note states that the *S. densiflora* tube is " strongly bent above the middle ".

As above mentioned, the anthers of *S. densiflora* are bluish black. The writer was at first suspicious that this colour was merely an early appearance of that blueing to which all *Strigas* are subject after plucking. Dissection of young flowers on the living plant however, dispelled this suspicion and showed that bluish-black is the natural colour of the anther.

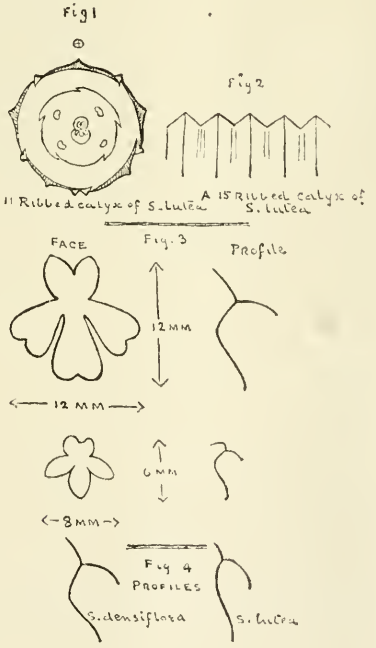
Specimens from different areas sometimes differ. Thus a plant of *S. densiflora* from Chharodi in Gujarat showed close packing of the flowers due to a shortening of the internodes, and increased scabridness with more serration of the leaves when compared with *S. densiflora* collected in Poona.

The writer has found *S. lutea* and *S. densiflora* growing together both in grass and on crops. This is also recorded by Barber and by Van Buuren.

III S. euphrasiodes :—The writer was for a long time unable to find this species in any grassland round Poona, although one specimen in the Poona herbarium had been collected at Pashan, a near-by village. At length a very few specimens were found in the area of waste land near the College of Agriculture in a piece of that land adjoining an irrigation distributory. At Chharodi in Gujarat this species was the common one, with occasional *S. densiflora* and no *S. lutea*, while at Tegur in the Dharwar District *S. euphrasiodes* was the only species found.

Van Buuren reported it on roots of grasses of the irrigation channel of the College Farm at Poona, and considered it more hygrophilous than the other species mentioned.

The diagnostic character of this species is the possession of 15 ribs, each main rib having on each side of it a secondary rib which runs right up to the tip of the calyx tooth.



Here again there is some variation in number, all the Chharodi specimens having 16 ribs, the additional rib being, as usual, anterior.

The writer came across one plant pink in the bud and also in the fully expanded corola. Van Buuren states: "At the approach of the dry season some plants which I had under observ-

ation showed a sensitiveness to drought. The leaves took on a purplish-red tinge while even the corolla had many fine streaks of the same colour, doubtless due to anthocyanin pigments."

The corolla length was found to be very variable with reference to the calyx length. No measurements were made.

IV. S. orobanchoides:— This is a well marked holoparasitic species in which the writer has noted no striking variations. It is not common in ordinary grasslands, the few specimens that the writer has seen being from a forest reserve on a hillside near Poona.

Conclusion

The Scrophulariaceœ is an order with apparently a history of variation, if one may judge by the sub-orders, classes and genera into which it is divided. *Striga* itself provides what is apparently a recent mutant. *Strigina*, described by Engler [1] differing from *Striga* in having the two anterior stamens reduced to staminodes. The question arises: Are the two colour forms of *S. lutea* and the plants with different sizes and shapes of corolla in *S. densiflora* to be put in different species? The only answer to this question can be got by growing the plants in pure culture, and up to date the writer has not succeeded in germinating *Striga* seed either by itself or in contact with host roots.

[1] Naturliche Pflanzenfamilien, Nachtrage zum IV. Teil.

NOTE ON THE GEOTROPIC CURVATURE OF THE INFLORESCENE IN EICHHORNIA SPECIOSA *KUNTH* (WATER HYACINTH.)

BY

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There are many striking peculiarities about the Water Hyacinth of which the bending of the inflorescence after flowering appears to be very noteworthy. The bending is seen in several stages but observation at definite intervals extending for a few days brings out certain interesting features which are briefly noticed below.

The inflorescence is an elongated erect spike with about 10-15 lilac or mauve coloured flowers arranged at the top of a long shoot. Flowers are medianly zygomorphic conforming to the formula P 3+3. A 3+3, G (3). There are two sheathing bracteal leaves, inserted one below the other, the lower having a distinct lamina.

The flowers in each inflorescence open simultaneously at about 8 o'clock in the morning, though occasionally a few may lag behind and open on the next day at the same hour.

With a view to ascertain the exact time of bending of the inflorescence I employed the Ganong's auxograph and placing the plant in position connected the tip of the inflorescence with a thread passing round the larger wheel. By tracing the curve on the cylinder which revolves once in an hour I found on the following morning that the curvature actually commences at about 10 in the night. Plants were also kept separately under observation and the interesting fact was noticed viz., that the closing of the flowers and the bending of the inflorescence occur simultaneously at about 10 P.M.

That the curvature is due to geotropism was proved in the following manner. A plant with flowers just open was fitted in a pot which was loosely packed with wet sponge so as to keep the roots moist. The pot was then fixed to the disc of a klinostat and rotated with the plant held horizontally. The roots were further kept moist by being watered at intervals. Though the flowers had closed as usual there was no curvature of the inflorescence even after three days. Hydrotropism does not play any part for the curvature took place when a plant was adjusted with the inflorescence horizontal and completely immersed in water. This shows that the curvature is the result of geotropism only.

The several stages in the process of bending are shown in the figure below. The actual bending is due to one sided growth at the portion immediately below the insertion of the two sheathing leaves. Examination of this part of the shoot before and after the curvature by marking it with india ink made this clear and it was further noticed that greater growth was as a rule opposite to the bladed sheath so that this was always lower in the curved inflorescence. A rapid bending is seen when the plant is in its best state of growth and the curvature is at two places, one at the base of the shoot and the other just beneath the bracteal leaves referred to above. The bends also appear as loops owing to the basal portion of the shoot being slow of response. The loops were observed in those cases where there was a delay in the development of the topmost flowers. The mutilation of such flowers brought about a similar result as also the complete removal of flowers just opened or of the inflorescence with unopened flowers a little above the insertion of the bracts. The loops were generally characteristic of plants in a poor state of growth. It is interesting to note that the > shaped curvature is reached on the sixth or seventh day of the opening of flowers.

A close study of the phenomenon as explained above shows that we are really dealing with two kinds of geotropic curvatures (1) the *positive geotropism* of the inflorescence resulting in its complete reversal and caused by a curvature beneath the insertion of the bracts, and (2) a *diageotropism* of the lower portion of the flowering shoot which corresponds to the internode of the sympodial vegetative axis and behaves as such



THE FORMATION OF LEAF-BLADDERS IN EICHHORNIA SPECIOSA, *KUNTH*, (WATER HYACINTH)

BY

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General:—Bladders in plants are comparatively rare and where they occur, they are of doubtful significance in most cases. The best known instances where such structures are conspicuously seen are *Sargassum*, *Fucus*, *Nereocystis* among the Fucaceæ, *Trapa* (Onagraceæ) species of *Utricularia*, and *Eichhornia speciosa* (Pontederiaceæ). Except in *Utricularia* where the bladder has been definitely proved to be an insect-catching and insect-preying organ, the functions of the bladders have been generally supposed to be either to serve as floatative or swimming organs or to serve as air reservoirs. In most of the above examples the ecological value has been better known rather than the physiological cause, and the present investigation was undertaken purely from the latter point of view. It applies only to *Eichhornia speciosa*, a study of which was made in the Botanical Laboratory at the Agricultural College and Research Institute, Coimbatore, where the weed attracted notice in connection with the proposed legislation for eradicating it in certain parts of the Madras Presidency.

Though *Eichhornia* is a water plant it thrives in such a variety of situations that observers have differed regarding its exact habitat. Kerner (7) for instance, states that the plants are not fixed in the mud beneath the water by roots but float freely on the surface of the pond. He further characterises *Eichhornia* as a swimming plant distinguishing it from floating plants like *Trapa* which are held fast to the muddy bottom beneath by means of roots. Schonland (10) on the other hand describes it more correctly as either swimming entirely and free on the water or rooting in shallow water in mud, the leaf stalks in the former case becoming strongly swollen and functioning as swimming bladders. Without seriously contradicting these authors it may be stated that plants with and without bladders are found in deep water the determining factor for bladder formation being, as will be seen below, not the depth but a plentiful supply of water that is physiologically available. The plant is also not restricted to any particular surrounding but is at home in ponds, tanks, old wells, ditches, in marshy areas and in fact in any stagnant

or slow moving fresh water of varying depths either as a free floater or rooted in the mud like a swamp plant. It is this indifference with regard to the habitat which makes it not the only troublesome weed that it is but also occasions the formation or not of bladders which are the most striking peculiarity about the plant. An examination of the plant in different surroundings will disclose four principal types, viz., (1) all the leaves of the plant with bladders; (2) all without bladders, (3) outer bladdered and inner bladderless, and (4) outer bladderless and inner bladdered.

Morphology :—In its best development the bladder is a rounded or pear-shaped structure 1 to $1\frac{1}{2}$ in. in diameter, representing the



whole of the leaf stalk and separated from the lamina by a short neck and narrowed at the base. From ten to fifteen leaves become closely aggregated together so as to form a rosette, and from the axils of many of the leaves new shoots arise which end in similar rosettes and originate fresh shoots in their turn. In this way are formed chains of sympodes radiating in all directions and covering a wide expanse of water in a surprisingly short period. Along with these there are also plants in which the bladders attain various stages of development leading to those which show only a slight swelling in the stalk or to its complete disappearance. These do

not produce such a large number of axillary shoots, nor do they exhibit such a pronounced rapidity of growth as is seen in the other plants. The transitional forms are shown in the diagram below.

Physiology :—In order to find out the behaviour of the plant in culture, I had a bladderless plant transferred to a jar containing the necessary salts dissolved in rain water according to Crone's formula. The appearance in a few days of swollen leaf stalks suggested that the chief stimulating factor was water and an examination of both bladdered and bladderless leaves would, it was thought, disclose either some difference in the water content or some sort of constitutional change brought about by the excess or deficiency of water. It is well known that stomata regulate their openings according to the amount of water present in the transpiring organs and thereby prevent too much loss of water from plants. A greater water content will thus keep them open whereas a diminished supply will tend to the closing of the aperture. A highly useful method of ascertaining the width of the stomatal opening is afforded by the work of Iljin (6) on the regulation of stomata. This author and Lloyd have shown that simultaneously with the opening of the stomata, the starch present in the guard cells disappears in some way probably by enzymic activity in the presence of a greater quantity of water and increases again when the water becomes less, as happens for instance during the day when transpiration gets more and more intense. As open stomata are sometimes found even in wetted plants, the appearance of starch does not so much indicate the closure of the stomata as a diminution of the water content in the guard cells and the leaf as a whole. By employing chloral-hydrate-iodine as a delicate test for starch, I examined the stomata of both kinds of leaves at different times during the day. The corresponding youngest leaves were chosen and the results which were confirmed by repeated observations are as follows, the drawings having been made with the help of the Zeichen Apparate.

The conclusions arrived at are :—

(1) that young leaves with bladders or with a tendency to bladder showed very little starch in the guard cells of the stomata which indicates a high-water content in the leaf.

(2) that leaves without bladders always contained more starch which is doubtless a response to the low-water content of the leaf.

It thus appeared possible that the bladders could be induced to form by making the water available to its utmost capacity, and I succeeded in this by growing a plant without bladder in Crone's solution of low concentration, viz., 1 in 1000. Plants were also grown in Sach's solution of normal concentration and in tap-water of the laboratory which is relatively higher in salts. The latter showed no

distension of the stalk whereas the one in Crone's solution responded to the medium and appeared with bladders of the intermediate type already shown above. It was also noticed that the absorption of water from the dilute solution was so enormous that after a warm day when the Temperature suddenly cooled down from 86°F at 3 P.M. to 76°F at 5 P.M. there was copious exudation of water from the apex which was not the case in the other two plants. It may, in this connection, be pointed out that the function of the apical gland appears to be rather to serve as a hydathode than as an absorbing organ as maintained by Goebel (2).

Anatomy:—As an effect of this high-water content notable changes are brought about in the growth of the leaf stalk. The turgidity of the cells is maintained by a high hydrostatic pressure which leads to the dilution of the cell sap as evidenced by the fact that the cells plasmolyse readily with a 1/5 normal solution of potassium nitrate, whereas this concentration is only just enough to overcome the rigidity of the cells in the long stalked leaf. The living cells of the leaf stalk thus become so much gorged with water that a plastic stretching of the cell walls ensues due to superficial growth, and as the cells of both transverse and vertical layers are subjected to this process the stalk assumes a spherical distension comparable to an inflated bladdder, and is filled with numerous polyhedral chambers bounded by layers of thin-walled cells (diaphragms) in an extremely stretched condition. Owing to this plastic stretching from the beginning the intercellular spaces in the diaphragm are considerably reduced and are practically confined to the periphery. Against this may be contrasted the structure of the bladderless stalk. This shows numerous air cavities which are partitioned by diaphragms but these are pierced by intercellular spaces from the earliest stage which points to the absence of any stretching due to turgidity. The intercellular spaces arise by the separation from each other of the walls of the diaphragms cells at several points and the air cavities communicating in this way evidently facilitate rapid diffusion of gas from the aerial organs to the root-system which is badly aerated, being fixed in mud or under other conditions referred to below. In the bladdered leaves, however, the diffusion of air contained in the chambers must be a slow process occurring only through the cell walls as the cavities do not communicate with each other. The presence of needle shaped crystals of calcium oxalate in considerable amounts also suggests the previous formation of oxalic acid which probably maintains a high osmotic pressure owing to the peculiar conditions which lead to the diminished water content. The principal changes in the anatomy are shown below:—

Discussion :—From the whole of the evidence available it seems reasonable to attribute the appearance and disappearance of the bladder to changes in the medium which influence the absorption of water in each case. Firstly, there are plants swimming in deep water which is freely exposed to light and air and in which the maximum absorption is facilitated by a low concentration. The primary effect of such a decrease in the osmotic concentration is, as Livingston (VIII) points out, " to add water to the organism whereas an increase in the concentration has a drying effect ". Secondly, there are plants in deep water crowded together so closely that light does not penetrate into it and the medium is also relatively lower in temperature. Thus a difference of 1° C was noticed in the same pond at noon on a sunny day up to 18 inches depth in the midst of the two kinds of plants. The roots in such plants are also covered by the mass of putrefying remains of the older leaves and roots which necessarily produce carbondioxide and various toxins that check rapid absorption of water. Thirdly, when plants are fixed to mud the roots become subject to (1) deficiency of oxygen, (2) coldness of the soil, and (3) higher concentration of water. The greater absorption of water or its check is thus due not to any single factor but to the co-operation of numerous factors which determine the water content of the plant. This water content may be best defined as " a function of the relation that has previously obtained between the rates of water entrance and of water exit," " it being immaterial whether it becomes low through high rates of water loss, or through low rates of water intake " (Livingston, Ed. of Palladin's Plant Physiology), (9). It also appears possible that the very early development of axillary shoots resulting in the formation of the sympodium deprives the original shoots of water and an elongation of the stalk beneath the bladder is rendered impossible. This is well seen in the absence of swellings in the later formed leaves and in the actual elongation of the stalk when the axillary shoots are slow of development.

The question then arises about the real nature of the plant. From the facts stated above it will be clear that the distension of the stalk is not so much an adaptation as a self-adjustment to the medium which aquatics in particular display owing to the extreme plasticity of organs characteristic of them. Goebel (3) who paid some attention to this question in his *Pflanzen biologische Schilderungen* confesses the inadequacy of the explanation on biological grounds, for the bladders are formed above water and the leaf floats with or without it. He noticed the disappearance of the swelling in the later formed leaves though the illustration (4) given in support of this actually resembles one of the transitional stages in which the leaves undergo a partial swelling. A study of the life

history of the plant should of course reveal its real nature. Unfortunately the seeds are difficult to germinate and require special conditions as shown by Crocker (1). But from the appearance of a germ shoot, *Keimpflanze*, figured by Goebel (5) it may safely be concluded that the rosettes of bladdered leaves are merely reversion shoots which are exhibited owing to an innate hereditary tendency present in the plant when the maximum facilities for growth are provided.

In conclusion, I desire to express my sincere thanks to M.R.Ry Rai Bahadur K. Rangachariar Avergal, for suggestive criticism and encouragement during the progress of this work and for ample facilities provided.

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Explanation of Figures opposite.

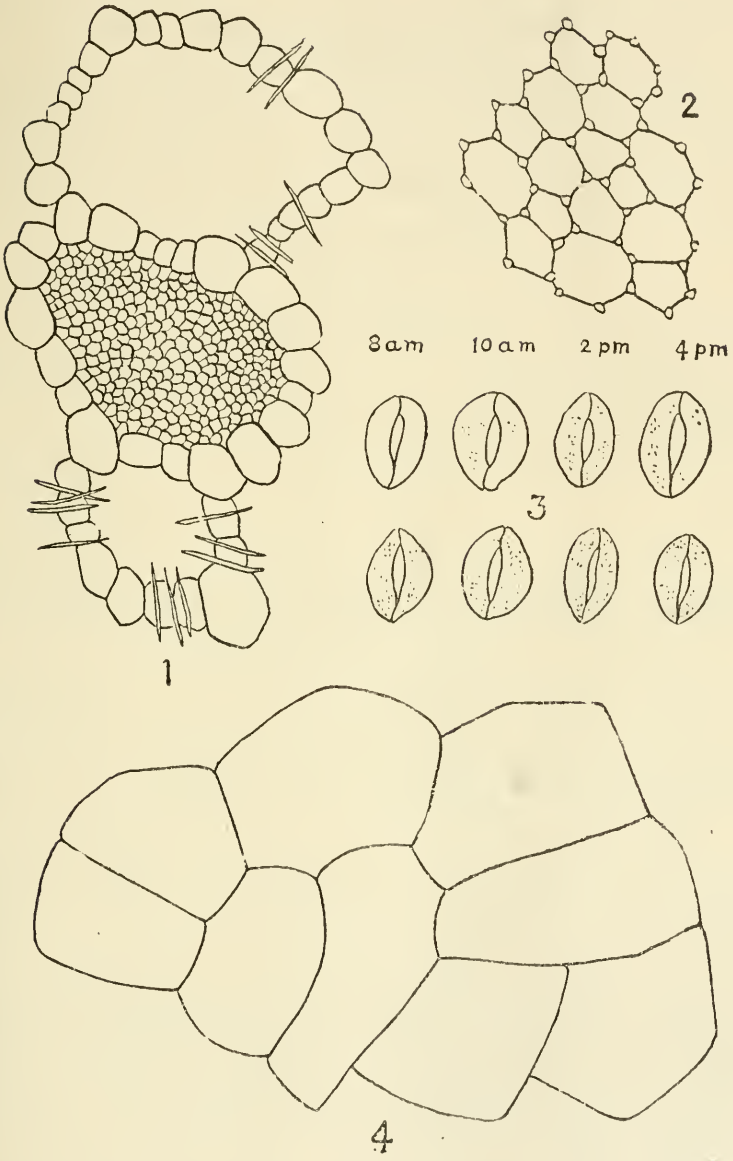
1. Large spaces in the leaf-stalk, bounded by diaphragms, in which lie crystals of Ca. oxalate.

2. Diaphragm cells in stalk without bladder.

3. Stamata in leaf with bladder—upper row.

 Do. without bladder—lower row.

4. Diaphragm cells in stalk with bladder.


2
8 a m
10 a m
2 p m
4 p m
3
1
4

CONTRIBUTIONS TOWARDS A FLORA OF BALUCHISTAN.

From materials supplied by Col. J. E. B. Hotson, I.A.R.O.

BY

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(*Continued from last issue*)

Gentianaceae

Erythræa *Renealm.*

Erythraea ramosissima *Pers. Syn. I, 283.*—Loc.: Nagak (W. Kolwa), about 87 miles E. by N. of Turbat, about 2,400 ft. (no. M227, M227A).—Fl. and fr. in April 1918.—

Vern. Name: Puliko (? Bal.).

Boraginaceae.

Cordia *L.*

Cordia obliqua *Willd. Sp. Pl. I, 1072.*—Loc.: Manguli, 197 miles SSW of Kalat (no. 235); Nag (W. Kolwa), about 83 miles E, by N. of Turbat, about 2,300 ft. (no. M236). Fl. in April 1918.—

Vern. Names: Lewar (Bal.), Jam (Bal.), Livar (Br.).

Heliotropium *L.*

Heliotropium Eichwaldi *Steud. ex DC. Prodr. IX (1845) 535.*—Loc.: One mile NE of Panjgur (M231A); Turbat, 63° 4′ E,25° 58′ N, about 600 ft., growing wild in water channels in a garden (no. M54).—Fl. in Feb. and May 1918.—Fr. in May 1918.

Vern. Name: Kapochisk (Bal.).

Heliotropium calcareum *Stocks in Kew Journ. Bot. IV (1852) 174.*—Loc.: Kuldan (W. Kolwa) about 85 miles E. by N. of Turbat, about 2,400 ft. (no, M 245); Zahren Kahur, 16 miles N. of Pasni, about 200 ft. (no. M21A); Rari Dan, 170 miles W. of Kalat, 2,300 ft. (no. 287); Paharmar, 25 miles S. of Wad about 3,650 ft. (no. 376); Hills near Ispikan, about 20 miles NE of Mand, about 1,200-1,500 ft. (no. M91); Mantar Juzbaf, about 40 miles S. of Panjgur, about 3200 ft. (M204); near Kuldan (W. Kolwa), about 85 miles E. by N. of Turbat, about 2400 ft. (no. M231).—Fl. in Feb. (Br.), to April 1918, Oct. 1917.—

Vern. Names: Kapochisk, Nilo, Kodalo (Bal.), Mashna Popat Popat (Br.? Bal.).

Heliotropium paniculatum *R. Br. Prodr. (1810) 494.*—Loc.: Kanoji, 47 miles N. of Las Bela, about 3200 ft. (no. 385); Rari Dan, 170 miles S. by W. of Kalat, 2300 ft. (no. 282). Fl. and fr. in Sept. and Oct. 1917.—

Vern. Name: Nambo (Br.).

Heliotropium rariflorum *Stocks in Kew Journ. Bot. IV (1852)* 174.—Loc.: Rar Kaur, 165 miles S. by W. of Kalat, about 3,500 ft. (no. 298).—Fl. in Sept. 1917.—

Vern. Name: Kolbur (Br.).

Heliotropium undulatum *Vahl Symb. I, 13.*—Loc.: Pusht Kuh (Kharan) about 26 57 N, 56 12 E, about 3500 ft. (no. M301); Garmkan, 1 mile NE of Panjgur, about 3125 ft. (no. M164); Dukop (no. M11A); Wahir, 25 miles S. by W. of Khozdar, about 4,200 ft. (no. 369).—Fl. and fr. in March and Apr. 1918, Oct. and Dec. 1917.—

Uses: The plant is crushed and soaked in water, and the water is dropped into the eyes if they are sore. (Hotson).

Vern. Names: Sahag Daru (Br.), Shimilo (Bal.).

Heliotropium Aucheri *DC. Prodr. IX, 533,*—Loc.: Kalat, about 3650 ft. (no. M397, 402). Common on roads and dry places.—Fl. and fr. in July 1918.

TRICHODESMA *R. Br.*

Trichodesma africanum *R. Br. Prodr. (1810) 496.*—Loc.: Hills near Ispikan, about 20 miles NE of Mand, about 1,200-1,500 ft. (no. M 100); near Ispikan (no. M 88 A).—Fl. and fr. in March 1918.—

Vern. Name: Charmaing.

ARNEBIA *Forsk.*

Arnebia hispidissima *DC. Prodr. X (1846) 94.*—Loc.: Harboi, 18 miles ESE of Kalat, 9000 ft. (no. 62).

Vern. Name: Mashana Mor Puzho (Br.).

Arnebia cornuta *F. & M. ?*—Loc.: Junction of Raghai and Sichk river.

GASTROCOTYLE *Bunge.*

Gastrocotyle hispida *Bunge in Men. Sav. Etr. Petersb. VII (1847) 405.*—Loc.: Harboi, 18 miles to SE of Kalat, 9,000 ft. (no. 60), Fl.—and Fr. in March 1917.—

Uses: Sheep, etc. eat this (Hoston).

Vern. Name: Mashana Talkha (Br.)

Convolvulaceae.

CONVOLVULUS *L.*

Convolvulus fruticosus *Pall. ex Ledeb. Fl. Ross. II, 734.*—Loc.: Surab, 28° 29′ N, 66° 16′ E., about 5,700 ft. (no. M 382).

Convulvulus microphyllus *Sieb. ex Spreng. Syst. I (1825) 611.*—Loc.: Goshanag, about 16 miles E. of Chambar (Kolwa), about 1780 ft. (no. M 273); Chib, 63° 8′ E, 26° 19′ N, about 1,600 ft., on border of irrigation channels (no. M 127); Pirandar, 205 miles SSW of Kalat, about 1,500 ft. (no. M 255).—Fl. in March and April 1918

Vern. Names: Ispephul. (? Bal.), Pulako (? Bal.).

Convolvulus sp. vicinus C. rhyniospermo *Hochst.*—Loc.: Pirandar, 205 miles SSW of kalat, about 1900 ft.—Fl. in Sept. 1917.—The corolla is half the size of that of C. rhyniospermus; the whole plant is much more hirsute.

Convolvulus spinosus *Burm. f. Fl. Ind. 47, t. 19, fig. 4.*—Loc.: between Mashkai and Pirandar, some 200 miles from Kalat, about 2,500 ft. (no. 250); Nasirabad, 23 miles W. of Turbat, about 400 ft. (no. M58); Kalgali Kaur, N. of Zaiaki Jangar (Kharan), about 4800 ft. (no. M345); Hazarganji (no. 25A); Hazarganji, 27° 28′ N, 66° 12′ E, about 3600 ft. (no. 250 A); near Sitani, 59 miles S.of Kalat, 5,300 ft. (no. 134); Benn Chah, 22 miles N. of Surab, about 6,200 ft. (no. M58C); Zaham, about 52 miles S. of Panjgur, about 2,800 ft. (no. M58A): Jatu Pass, N. side, about 32 miles SSW of Paujgur about 3,300 ft. (no. M200); Panjgur, about 3100 ft. (no. M71), M 58B). —Fl. and fr. in Sept. 1917, March, April and May 1918.

Vern. Names: Delaku (Panjguri Bal., Br.), Dolaku (Panjgurf Bal.), Dolaku (Kachi Bal.), Dohalok (Mandi Bal,). Pulerpit (Bar.,) Girdpit.

Convolvulus arvensis *L. Sp. Pl. (1753) 153.*—Loc.: Harboi, 9,000 ft. (48B); Harboi, 18 miles ESN of Kalat, 9,000 ft. (no. 48); Surab (Jhelawan), 28° 29′ N, 66° 16′ E, about 5,700 ft (no. M380); Surab (no. M380A); Kudabadan, ¼ mile N of Panjgur, about 3,100 ft. (no. 152A); Ornach, 3080 ft (no. 317); Hazarganji, 27° 28′ N, 66° 12′ E, about 3,600 ft. (no. 333); Kalat, about 3650 ft. (no. M380) B, C, and D); Panjgur, about 3,100 ft. (no. M52). Fl. in AUG. and Sept. 1917, March and July 1918. Fr. in Sept. 1917.

Vern. Names: Pechok, Pech, Gul Pech (Br.), Wakarwali, (Sarawan Br.), Mazhgalak (Jhalawan Br.), Ligirk, Likirk (Bal.), Marwal (Sind.).

Convolvulus Rottlerianus *Chois, Cony. Or. in Mem. Soc. Phys. Genyey. VI (1834) 477.*—Loc.: Chib (no. Ml 27 A); Wahir (no. 370). Fl. in March 1918, Fl. and fr. in Oct. 1917.

Convolvulus sp., Convolvulo congloyerato vicinus Loc.: Garroki Kaur, 32 miles N. of Pasni, about 350 ft. (no. M 51); near Kaur Dat, about 13 miles N. of Rekin (Kolwa,) about 1950 ft. (M51B); Barit Pass, between Pirandar and Nundara, about 2000 ft. (no. 265); Rekin (Awaran, Kolwa) 26 24 N, 65 12 E, about 1,750 ft. (no. M51A); Hills near Ispikan (M83A); Hills near Ispikan, say 20 miles NE of Mand, about 1200 ft.—Fl. in Sept 1917, February to April 1918.—

Uses: The roots of this plant, when soaked in water, make a strong purgative. (Hotson).

Vern. Names: Ritachk (Bal., Br.), Delaku (Bal.), Khargoshkah (Bal.).

Evolvulus *L.*

Evolvulus alsinoides *L. Sp. Pl. ed. 2′:(1762) 392.*—Loc.: Hushtar Rahi Kaur 160 miles S. of Kalat, about 3,700 ft. (no. 308).

Cressa *L.*

Cressa cretica *L. sp. Pl. (1753) 223.*—Loc.: Hazarganji, 27 28 N, 66 12. E, about 3,600 ft. (no. 330).—Fl. and fr. in Sept. 1917.

Vern. Name: Nambo (Br.).

Cuscuta *L.*

Cuscuta europaea *L. Sp. Pl. 124.*—Loc.: Surab (Jhalawan), 28 29 N, 66 16 E, about 5,700 ft. (no. M376).—Fl. and fr. in June 1918. Parasitic on Euphorbia sp.

Cuscuta monogyna *Vahl Symb. Bot. II, 32.*—Loc. not given.—Parasitic on Sophora alopecuroides.

BREWERIA *R. Br.*

Breweria latifolia *Benth. ex C. B. Clarke in Hook. f. Fl. Brit. Ind. IV (1,883) 224.*—Loc., Hushtar Rahi Kaur, 160 miles S. of Kalat, about 3,700 ft. (no. 302); Mandi Parag, 22 miles E. of Chambar, about 1.900 ft. (no. M 278) Pirandar, 205 miles SSW of Kalat, ca 1,900 ft. (no. 261) Fl. and fr. in Sept. 1917.

Vern. Name: Puributi (Bai., Br.)

IPOMŒA *L.*

Ipomoea biloba *Forsk. Fl. Aegypt.—Arab. (1,775) 44.*—Loc.: Pasni, 63 28 E, 25 17 N, seashore. (no. M 46 A and M 46). Fl. in Feb. 1918.

Note: This plant was introduced by the Telegraph Dept. from Karachi in an attempt to keep the drifting sand under control. It is now well established (Hotson).

Vern. Name: Softakh? (Brah.), Nangwal (Sind., Bal.)

Ipomoea sagittata *Desf. Atl.I, 177.*—Loc.: Between Kanoji, 47 miles, and Kohanwat, 21 miles N. of Las Bola, 3,500 to 1,400 ft. (no. 393 C and D); Diria Gada river, 32 miles N. of Las Bela, about 2,500 ft. (no. 393 E).

Vern. Name: Wal.

Solanaceae.

SOLANUM *L.*

Solanum nigrum *L. Sp. Pl. (1753 (186.*-Loc.: Khudabadan, ¼ mile N. of Panjgur, about 3.100 ft. (no. M 192, M 192 A); Surab, 43 miles S. of kalat, 5,750 ft. (no. M 108).—Fl. and fr. in March 1918. Fl. in Aug. 1917.

Uses: The berries are eaten for pleasure and for pains in the stomach (Hotson).

Vern. Name: Tolangur (Bal., Br.).

Solanum indicum *L. Sp. Pl. (1,753) 187.*—Loc.: Under the Baran Lak, about 28 miles S. of Wad, on the way to Las Bela, about 3,900 ft. (no. 376 A). Fr. in Oct. 1917.

Vern. Name: Kauratrim (Br.).

Solanum incanum *L. Sp. Pl. (1,753) 188.*—Loc.: Near Manguli, 197 miles SSW of Kalat, about 2,450 ft. (no. 240); Pirandar, 205 miles SSW of Kalat about 2,000 ft., and Korak (Pelar) 180 miles S. by W. of Kalat, about 1,900 ft. (no. 240 A); Hushtar Rahi Kaur, 160 miles S. of Kalat, about 3,700 ft. (no. 240B) Fl. and fr. in September 1917.

Uses: The fruit is said to be used as medicine for horses (Hotson).

Vern. Names: Bahir (Bal., Br.), Kaura Trim (Br.)

Solanum xanthocarpum *Schrad. and Wendl. Sert. I (1795) 8, tab. 2.*—Loc.: Baran Lak, about 28 miles S. of Wad, about 3,900 ft. (no. 376). Fl. in Oct. 1917.

Vern. Name: Kaura Trim (Br.).

Solanum gracilipes *Dlne. in Jacq. Voy Bot. (1844) 13, t. 119.*—Loc.: Bar Kaur 165 miles S. by W. of Kalat, about 3,500 ft. (no. 300: Hills S. of Chambar (Kolwa), 26° 9′ N, 64° 42′ E, about 2,300 ft. (no. M 36B); near Chambar (no. M 36D).—Fl. in Sept. 1917, April 1918. Fr. in April 1918.

Vern. Names: Putrunk (Bal.,), Gwangir (Br.).

Capsicum. *L.*

Capsicum annum *L.* var **acuminata** *Fingerh. Monogr. Gen. Caps. (1832) 13, t. 2.* Loc.: Korak (Pelar) 180 miles S. by W. of Kalat, 1,900 ft. (no 270. 270A).—Fl. and fr. in Sept. 1917.

Vern.Name: Soren Pirpir (Bal.). The common Chili.

Withani *A. Pauq.*

Withania somnifera *Dunal in DC. Prodr. XIII (1852) 453.*—Loc.: Jobri, 147 miles SSW of Kalat, 3,850 ft. (no. 223); Ornach, 27° 0′ N, 66° 10′ E, about 3,080 ft. (no. 319, 319A); Tump 46 miles W. of Turbat, about 600 ft. (no. M 61) Fl. and fr. in Sept. 1917, March 1918.

Vern Names: Kangerishk (Bal.), Lal Gogharo (Br.); Kakink (Bal.)

Withania coagulans *Dunal in DC. Prodr. XIII (1858) 685.*—Loc.: Gidardhor, below Shandadzai, about 80 miles S. of Kalat, about 4,900 ft. (no. 154); Ispikan, 16 miles NE of Mand, about 1050 ft. (no. M77); Mantar Juzhaf, about 40 miles S. of Panjur, about 3200 ft. (no. M 77A); Pishuk, 16 miles NE of Nag (Kharan), about 5200 ft. (no. M77B, M77 C). This is one of the commonest plants in the upper part of the Robhohan valley, beginning some 30-40 miles ENE of Panjgur. It is a some what uncommon plant in Makran, though widely spread.—Fr. in June 1918.

Uses: Besides curdling milk it is said to be used as an intoxicant. The leaves are ground up and used like baang. The berries are crushed and mixed with water and used as a medicine.

Vern. Name: Panerband or Panirband (Bal., Br.).

Lycium *L.*

Lycium barbarum *L. Sp. Pl. (1753 192.*—Loc.: Kochau, 122 miles SSW of Kalat, 4,150 ft. (no. 120A); Nal, 27° 41′ N, 66° 13′ E, 3834 ft. (no. 120C); Dokop, 60 miles W. of Turbat, about 700 ft. (no. M10, M10A.); Zahren Kahur 16 miles N. of Pasni, about 200 ft. (no. M 10B); 5 miles N. of Mand about 1,000 ft. (no. M10C); Tapk, about 62° 50′ E, 26° 19′ N, about 1,750 ft. (no. M10 D); Mazhdalu, about 20 miles S. of Panjgur, about 3,000 ft. (no. M10 E); near Kuldan (W. Kolwa), about 85 miles E by N of Turbat, aboht 2,400 ft. (no. M10 F); Ispikan, 16 miles NE of Mand, about 1,050 ft. (no. M 76).—Fl. in Sept. and Dec. 1917. Fr. in March and April 1918, Sept. and Dec. 1917.

Vern. Names: Zirok (Bal.), Kotor (Bal, Br.)

Lycium ruthenicum *Murr. in Comm. Getting. 1779. p. 2.*—Loc.: Hazarganji, 27° 28′ N, 66° 12′ E, about 6,300 ft. (no. 328, and 328A). Mohtaji kand, about 22 miles SW of Panjgur, about 2,800 ft. (no. M 132, M 132A).—Fl. and fr. in March 1918, Sept. 1917.

Vern Name: Jharakh, Jarok (Bal.).

DATURA *L.*

Datura stramonium *L. Sp. Pl. 179.*—Loc.: Sitani, 59 miles S. of Kalat, 5,300 ft. (no. 125); Pirumar, 16 miles S. of Khozdar about, 4,100 ft. (no. 125B). Fl. and fr. in Aug. and Sept. 1917.

Vern. Name: Dhatura (Br., etc.).

HYOSCYAMUS *L.*

Hyoscyamus muticus *L. Mant. (1767) 45.*—Loc.: Hodal Pass, N. side, about 80 miles S. of Panjgur, 2,200-2,900 ft. fairly common on the pass. Not yet in flower in April 1918.

Vern. Name: Kohibang (Bal.).

Hyoscyamus pusillus *L. Sp. Pl. 180.*—Loc.: Manguli (Jhalawan) 26° 45′ N, 65° 21′ E, about 2,600 ft. (no. M297, M2M 97A).—Fl. and fr. in April 1918.

Uses: The seeds are reputed to be acure for tooth-ache.

Vern. Name: Dantanshan (Bal.).

Scrophulariaceae.

ANTICHARIS *Endl.*

Anticharis glandulosa *Aschers. in Monatsber. Akad. Wiss. Berl. 1866) 880.*—Loc.: Near Manguli, 197 miles SSW of Kalat, about (2,450 ft. (no. 247), Korag (Pelar), 180 miles S. by W. of Kalat, 1,900 ft, (no. 268); Salao, 46 miles N. of Las Bela, about 300 ft. (no. 391A); Kanoji, 47 miles N. of Las Bela, about 3,100 ft. (no. 390).—Fl. and fr. from Sept. to Oct. 1917.

Uses: This plant is dried and used as soap.

Vern. Names: Badro (Br.).

LINARIA *Juss.*

Linaria cabulica *Benth. in DC. Prodr. X, 270.*—Loc.: Bar Kaur, 165 miles S. by. W. of Kalat, about 3,500 ft. (no. 297). Fl. in Sept. 1917.

Vern. Name: Wal (Bal., Br.).

SCHWEINFURTHIA *A. Br.*

Schweinfurthia sphaerocarpa *R. Br.* in Monatsb. Akad. Wiss. Berl. (1866) 875.—Loc.: Pirandar, 205 miles SSW of Kalat, about 1,900 ft. (no. 259); Hills near Ispikan, about 20 miles NE of Mand, about 1,200-1,500 ft. (no. M20A, M20B); Hills S. of Chambar (Kolwa), 26° 9′ N, 64° 42′ E, about 1,900-2,200 ft. (no. M20C); Mitasing, about 17 miles ESE of Panjgur, about 4,000 ft. (no. M20D).—Fl, in Sept. 1917. Fr. in April to May 1918.

Vern. Name: Drohond (Bal., Br.).

LINDENBERGIA *Lehm.*

Lindenbergia urticaefolia *Lehm. Ind. Sem. Hort. Berol. (1829) 1830, 5.*—Loc.: Rar Kaur, about 165 miles S. by W. of Kalat, about 3,200 ft. (no. 306); near Kaoji, 47 miles N. of Las Bela, about 3,200 ft. (no. 378A).—Fl. in Sept. and Oct. 1917.

Vern. Name: Matitao (Br.).

VERONICA *L.*

Veronica anagallis *L. Sp. Pl. (1753) 12.*—Loc.: Sitani (Jhalawan), 28° 19′ N, 66° 5′ E, about 5,300 ft. (no. M364, M364A) growing in moist places on the banks of water channels.—Fl. and fr. in June 1918.

ANARRHINUM *Desf.*

Anarrhinum orientale *Benth. in DC. Prodr. X, 289.*—Loc.: Harboi, 18 miles ESE of Kalat, 9,000 ft. (no. 54).—Uses: Sheep eat this, also goats, etc.

Vern. Name: Nila (Br.).

Anarrhinum *sp.*—Loc.: Pishuk, 27° 33′ N, 66° 18′ E, about 5,300 ft. (no. M341). Fr. in June 1918.

LEPTORHABDOS *Schrenk.*

Leptorhabdos virgata *Walp. Rep. III, 387.*—Loc.: Harboi, 18 miles ESE of Kalat, 9,000 ft. (no. 29, 29B, 42). Fl. after rain in Aug. 1917.—Uses: Eaten by sheep.

Vern. Name: Fisun Lathi (Br.).

Orobanchaceae

CISTANCHE *Hoffm. and Link.*

Cistanche tubulosa *Wight Ic. t. 1420, bis.*—Loc: Pirandar, 205 miles SSW of Kalat, about 1,900—2,000 ft. (no. 264, 264A); Las Bela, about 700 ft. (no. 264B). Fl. in Sept. and Oct. 1917.

Vern. Name: Machochik (Br.).

OROBANCHE *L.*

Orobanche aegyptiaca *Pers. Syn. II (1807) 181.*—Loc.: Quetta about 5,550 ft. (no. M403 A,B,C); Residency Garden at Quetta.—Fl, and fr. in July 1918.

Orobanche hirtiflora *Reut.*—Loc.: Kalat, 7,000 ft. (no. 7,); Surab, 43 miles S. of Kalat, 5,750 ft. (no. 7 A).—Fl. in Aug. 1917.—Uses: Eaten by camels and goats.

Vern. Name: Machochik (Br.).

Orobanche oxyloba *Reut.*—Loc.: Baluchistan.

Bignoniaceae.

TECOMELLA *Seem.*

Tecomella undulata *Seem. in Ann. & Mag. Nat. Hist. ser. 3, X (1862) 30.*—Loc.: Kochau (no. 198); Rekin (Awaran, Kolwa) 26° 24′ N, 55° 12′ E, about 1,750 ft. (no. M289): Gwambuk, about 60 miles S by E. of Panjgur, about 2,700 ft. (no. M23, M24D): about 6 miles E. of Mand, 62° 3′ E, 26° 7′ N, about 850 ft. (no. M23A, M23B).

One little nala was covered with these bushes in full flower, a most gorgeous sight. Though we saw many of these bushes later on we saw no more flowers. The colour is a brilliant, almost orange yellow. Fl. in March 1918, Bagai Daf (Mantar), about 42 miles S. of Panjgur, about 3,100 ft. (no. M23C), a row of these trees along a

cliff fall, just freshly green in April 1918. Only a few flowers Kavneh Kalat (Gichk), about 45 miles E. of Panjgur, about 3,750 ft. (no. M23E), groves of this tree in flower in April 1918. Two varieties are recognized: one is yellow with some reddish markings, the other yellow inside, reddish round the edges; Siahen Damb (Gichk), about 36 miles E. by S. of Panjgur, about 3,800 ft. (no. M23G), this is a pure yellow flower, April 1918; Siahen Damb (no. M231), a very deep red flower, April 1918; Siahen Damb (M23H), a red flower not so dark as the last, which grew on the same branch, these have no trace of the yellow centre, which is very commonly seen. It is almost leafless in February, in full flower in April; in Turkestan it flowers in November and December.

Uses: The wood of the yellow variety is hard, much used, that of the reddish variety is soft and of little value. The flowers are boiled and the water drunk (in cup fulls) for drieness of the liver and swollen belly.

Vern. Name: Parpuk (Bal., Br.)

Acanthaceae

Ruellia *L.*

Ruellia patula *Jacq. Misc. Bot. II (1781) 358.*—Loc.: Near Ornach, about 3,300 ft. (no. 316); Hushtar Rahi Kaur, 160 miles S. of Kalat, about 3,700 ft. (no. 307).-Fl. and fr. in Sept. 1917.

Blepharis *Juss.*

Blepharis edulis Pers *Syn. II, 108.*—Loc.: Between Mashkai and Pirandar valleys, 200 miles from Kalat, about, 2,500 ft. (no. 249); Kanoji, 47 miles N. of Las Bela. about 3,200 ft (no. 387).; Ben Chah, 25 miles N. of Surab (Jhalawan), about 6,200 ft. (no. M 387): near Kuldan (W. Kolwa), about 85 miles E. by N. of Turbat, about 2,400 ft. (no. M96A); near Bazdad, 25 miles E. of Chambar (Kolwa), about 1,850 ft. (no. M 96B).—Fr. in Sept. 1917, April 1918.

Uses: Said to be used as a green manure at the roots of vines.

Vern. Name: Sagi Dantan (Bal.).

Barleria *L.*

Barleria acanthoides *Vahl Symb. I, 47.*—Loc.: Hills S. of Chambal (Kolwa) 26° 9′ N, 64° 42′ E, about 2,200 ft. (no. M257).—Fr. in Apri 1918.

Peristrophe *Nees.*

Peristrophe bicalyculata *Nees in Vahl Pl. As. Rar. III, 113.*—Loc.: Dalna Khor, 29 miles N. of Las Bela, about 2,000 ft (no. 395).

Verbenaceae.

Lippia *L.*

Lippia nodiflora *Rich in Michx. Fl. Bor. Am. II. 15.*—Loc: Panjgur (M329H); Khozdar, 27° 48′ N, 66° 37′ E, about 4,100 ft. (no. 342).—Fl. in Sept. 1917 and May 1918.

Vern. Name: Gandago (Bal.).

VERBENA *L.*

Verbena officinalis *L. Sp. Pl. (1753) 20.*—Loc.: Jebri, 147 miles SSW of Kalat, 3,850 ft. (no. 225); Kozdar, 27° 48′ N, 66° 37′ E, about 4,100 ft. (no. 346).—Fl. and fr. in August and Sept. 1917.

Vern. Name: Sandol (Bal.).

VITEX *L.*

Vitex agnus-castus *L. Sp. Pl. 638.*—Loc.: Gidar Dhor, below Shahdadzai, about 80 miles S. of Kalat, about 4,900 ft. (no. 156) Garmkan, 1 mile NE of Panjgur, about 3,125 ft. (no. M 166); Panjgur, (no. M 166A). Fl. in May 1918.

Vern. Name: Gwanik (Bal., Br.).

Labiatae

OCIMUM *L.*

Ocimum basilicum *L. L. Sp, Pl. (1753) 597.*—Loc.: Korak (Pelar), 180 miles S. by W. of Kalat. 1,900 ft. (no 269). Fl. in Sept. 1917.

Vern. Name: Niazpu (Br.)

ORTHOSIPHON *Benth.*

Orthosi phonpallidus *Royle, MSS ex Benth. in Hook. Bot. Misc. III (1833)* 370.—Loc.: Baran Lak, 29 miles S. of Wad, about 4,100 ft. (no. 381). Fr. in Oct. 1917.

MENTHA *L.*

Mentha sylvestris *L. Sp. Pl. ed. 2,804.*—Loc.: Kalat, 7,000 ft. (no. 6; M 359A) Sitani (Gidar, Jhalawan), 28° 19′ N, 66° 5′ E, about 5,300 ft. (no. M359). Fl. and fr. in June to Aug. 1918.

Vern. Name: Purchink (Br., Bal.)

SATUREIA *L*

Satureia montana *L. Sp. Pl. 568.*—Loc.: Under Harboi 18 miles ESE of Kalat 8,300 to 9,000 ft. (no. 28). Fl. in Aug. 1917.

Vern. Name: Purchink (Br.).

Satureia *sp.*—Loc.: Spring on Harboi, 18 miles ESE of Kalat, 8,600 ft. (no. 64). Fl. in Aug. 1917.

Vern. Name: Mashana Sosingi (Br.).

PEROWSKIA *Karel.*

Perowskia abrotanoides *Kiril. in Bull. Mosq. (1841) 15, t. 1.*—Loc.: Harboi 18 miles ESE of Kalat, 9,000 ft. (no. 14B); N. side of Kalgali Pass (Jhalawan), about 28° 11′ N, 66° 1′ E, about 8,200 ft. (no. M235); Iskalku, 7 miles E of Kalat, 7,500 ft. (no. 14A), has a very wide area from about 6,000 ft. upwards, abundant in the 'kucha' pasture.—Fl. in June to Aug. 1917.

Uses: The flowers are soaked and the body of a man suffering from fever washed in the water; very cooling.

Vern. Name: Gwari drani (Br.).

SALVIA *L.*

Salvia aegyptiaca *L. Sp. Pl. (1753) 23.*—Loc.: Near Ornach, about 3,300 ft. (no. 313). Fl. and fr. in Sept. 1917.

Vern. Name: Kohi Maur (Bal.).

Salvia macilenta *Boiss. Diagn. ser. 1, 13.*—Loc.: Hills near Ispikan, about 20 miles NE of Mand, about 1,200-1,500 ft. (no. M85, M85A). Fl. and fr. in March 1918.

Vern. Name: Bo-i-Madaran (Bal.)

Salvia santolinaefolia *Boiss. Diagn. ser. 1. V. 13.*—Loc.: Zahren Kahur, 16 miles N of Pasni, about 200 ft. (no. M39); Ispikan 16 miles NE of Mand about 1,050 ft. (no. M39A); Chib (Buleda), 36° 8′ E, 26° 19′ N, about 1,600 ft. (no. M39C); Hills S. of Chambar (Kolwa), 26° 9′ N, 64° 42′ E, about 2,200 ft. (no. M258); Pangur (no. M85C); Manguli (Jhalawan), 26° 45′ N, 65° 21′ E, about 2,600 ft. (no. M90B): Hushtar Rahi Kaur. 160 miles S. of Kalat, about 3,700 ft. (no. M220A); Tapk, about 62° 50′ E, 26° 19′ N, about 1,750 ft. (no. M121); Siahen Damb (Jichk), about 36 miles E by S. of Pangjur, about 3,800 ft. (no. M317, M317A).—Fl. and fr. from Feb. to May 1918, Sept. 1917.

Vern. Names: Shwanko, Shwanago, Bo-i-Madaran, Bodpu (Bal.), Puzhu, Morpuzho, Maur, (Bal. Br.).

Salvia sclarea *L. Sp. Pl. 27.*—Loc.: Kalat, about 6,350 ft. (no. M392, M392A M392B); Kochau, 120 miles SW of Kalat, 4,150 ft. (no. 199). Hodal Pass (N. side) about 80 mile S. of Panjgur, 2,200-2,900 ft. (no. M218), fairly common on the Pass; Near Sitani, 59 Miles S. of Kalat, 5,300 ft. (no. 137); near Shahdadzai, 72 miles S. of Kalat, 5,100 ft. (no. 137A).—Fl. and fr. in July 1918.

Vern. Names: Bishkhaf (*bish* means donkey, *khaf* means ear), Maur (Br.), Mor (Bal.).

Salvia macrosiphon *Boiss, Diagn. ser.* 1, *pt. 11.*—Loc.: Mitasing, about 17 miles ESE of Panjgur, about 4,000 ft. (no. M218A, M218B).—Fl. in April 1918.

Vern. Name: Mor (Bal.).

ZIZIPHORA *L.*

Ziziphora clinopodioides *Lam. III. 1, 63.*—Loc.: Harboi, 18 miles ESE of Kalat, 9,000 ft. (no. 27, 27A). Fl. and fr. in Aug. 1917.

Uses: Regarded as a kind of mint.

Vern. Names: Purchink, Pudina.

NEPETA *Riv.*

Nepeta glomerulosa *Boiss. Diagn. ser. 1, pt. 21.*—Loc.: Harboi, 18, miles ESE of Kalat, 9,000 ft. (no.26, 72); Benn Chah, 22 miles N. of Surab (Jhalawan), about 6,200 ft. (no. M 384, M384A). Fl. and fr. in Aug. 1917.

Uses:—Eaten as a relish by men, also by sheep, very much liked by cats (Hotson).

Vern. Name: Simsok (Br.).

Nepeta bracteata *Benth. in DC. Prodr. XII, 395.*—Loc.: W. side of Burida Pass 140 miles SSW of Kalat, below 4,250 ft. (no. 26A),

Vern. Name: Simsok (Br.).

Nepeta sp. ?—Loc.: Hodal Pass, N. side, about 80 miles S. of Panjgur, 2,200-2,900 ft. (no M220); Kori Kaur, W. of Ornach, about 3,600 ft. (no. 309; Gwambuk, about 60 miles S. by E. of Panjgur, about 2,700 ft. (no.M 206).

Vern. Names: Simsur, Kalporag (Bal., Br.), Bodaku (Bal. ?).

MARRUBIUM *Tourn.*

Marrubium vulgare *L. Sp. Pl. 533.*-Loc.: Kalat, about 6,350 ft. (no. M 393). Fl. and fr. in July 1918.

Vern. Name: Borkash (Br.).

OTOSTEGIA *Benth.*

Otostegia Aucheri *Boiss. Diagn. ser. 1. pt. 40.*—Loc.: Tapk, about 26° 19′ N, 62° 50′ E, about 1,750 ft. (no. M120); Kuchkan, about 17 miles W S W of Panjgur, about 2,900 ft. (no. M120A and B); Pishuk, 27° 33′ N, 65° 18′ E. (Kharan), about 5,300 ft. (no M120D); Teghab, 107 miles S. of Kalat, 4,150 ft. (no. 181); Wad 27° 20′ N, 66° 20′ E, about 4,000 ft. (no. 373); Nal, 27° 41′ N. 66° 13′ E, 3834 ft., very common (no. 337).; Panjgur, (no. M214B). Fl. and fr. from Aug. to Sept. 1917, May and June 1918.

Vern. Names: Samar (Bal., Br.), Sadikh (Br.), Kulinch ?.

TEUCRIUM *L.*

Teucrium stocksianum *Boiss. Diagn. ser. 2, IV, 58.*—Loc.: Hills near Ispika, about 20 miles NE. of Mand, about 1,200-1,500 ft. (no. M82); Wahir 25 miles S. by W. of Khozdar, about 4,200 ft. (no 309 A).—Fl. in Sept. 1917.

Vern. Name: Kalporag (Bal. Br.)

(*To be continued.*)

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Important Notice

During my absence from India on furlough the editing of this journal will be in the hands of the

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THE PHYSIOLOGICAL ANATOMY OF THE PLANTS OF THE INDIAN DESERT

BY

T. S. SABNIS, B.A., M.Sc.

St. Xavier's College, Bombay.

(*Continued from p. 197.*)

PAPILIONACEAE—(*Contd*).

Crotalaria Medicaginea *Lam.*—Figs. 102, 103. Epidermal cells tabular. Mesophyll bifacial. Veins embedded and enclosed in bundle-sheaths. Tannin sacs found near the veins. External glands absent. Assimilatory tissue in the axis parenchy-matous. Pericycle formed of stone-cells. Medullary rays uniseriate. Pith formed of thin-walled cells.

Indigofera linifolia *Retz.*—Epidermal cells tabular. Mesophyll isobilateral; Veins embedded and enclosed in bundle-sheaths. Tannin sacs in the middle of the mesophyll, in cortex and pith. Clothing hairs in the form of two-armed trichomes. External glands absent. Assimilatory tissue in the axis chlorenchymatous. Pericycle formed of bast fibres. Medullary rays uniseriate. Pith formed of thin walled cells.

Indigofera cordifolia *Heyne.*—Figs. 104, 105. Epidermal cells tabular. Mesophyll isobilateral. Veins embedded and enclosed in bundle-sheaths. Tannin sacs in the middle of the mesophyll, in cortex and pith. Clothing hairs in the form of two-armed trichomes. External glands absent. Assimilatory tissue in the axis chlorenchymatous. Pericycle formed of bast fibres. Medullary rays uniseriate. Pith formed of thin-walled cells.

Indigofera paucifolia *Del.*—Figs. 106, 107. Epidermal cells tabular, Mesophyll isobilateral. Veins embedded and enclosed in bundle-sheaths. Tannin sacs in the palisade tissue, in cortex and pith. Clothing hairs in the form of two-armed trichomes. External

glands absent. Assimilatory tissue in the axis chlorenchymatous. Pericycle formed of bast fibres. Medullary rays 1-2 seriate. Pith formed of thick-walled cells.

Indigofera argentea *Burm.*—Epidermal cells tabular. Mesophyll isobilateral. Veins embedded and enclosed in bundle-sheaths. Tannin sacs in the middle of the mesophyll, in cortex and pith. Clothing hairs in the form of two-armed trichomes. External glands absent. Assimilatory tissue in the axis chlorenchymatous. Pericycle formed of bast fibres. Medullary rays uniseriate. Pith formed of thin-walled cells.

Indigofera anabaptista *Steud.*—Epidermal cells tabular. Mesophyll isobilateral. Veins embedded and enclosed in bundle-sheaths. Tannin sacs in the middle of the mesophyll, in cortex and pith. Clothing hairs in the form of two-armed trichomes. External glands absent. Assimilatory tissue in the axis chlorenchymatous. Pericycle formed of bast fibres. Medullary rays uniseriate. Pith formed of thick-walled cells.

Psoralea odorata *Blatt. and Hall.*—Figs. 108. Epidermal cells tabular. Mesophyll isobilateral. Veins vertically transcurrent by means of colourless parenchyma and enclosed in bundle-sheaths. Tannin sacs found near the veins and in the soft bast. Intramural glands found in the leaf. Clothing hairs appressed and muriculate. External glands club-shaped. Assimilatory tissue in the axis chlorenchymatous. Pericycle formed of bast fibres. Medullary rays uniseriate. Pith formed of thick-walled cells.

Tephrosia incana *Grah.*—Epidermal cells tabular. Mesophyll bifacial. Veins vertically transcurrent by sclerenchyma. Veins provided with bundle-sheaths. Clothing hairs in the form of uniseriate trichomes with muriculate walls. Pericycle composed of groups of stone-cells. Tannin sacs in the middle of the mesophyll. External glands absent. Assimilatory tissue in the axis chlorenchymatous. Pericycle formed of stone-cells. Medullary rays uniseriate. Pith formed of thin-walled cells.

Tephrosia multiflora *Blatt. and Hall.*—Epidermal cells tabular. Mesophyll bifacial. Veins vertically transcurrent by sclerenchyma and provided with bundle-sheaths. Clothing hairs in the form of uniseriate trichomes with muriculate walls. External glands absent. Pericycle formed of groups of stone-cells. Tannin sacs in the middle of the mesophyll. Assimilatory tissue in the axis chlorenchymatous. Pericycle formed of stone-cells. Medullary rays uniseriate. Pith formed of thin-walled cells.

Alysicarpus vaginalis *DC.*—Figs. 109, 110, 111. Epidermal cells tabular with outer walls toothed. Mesophyll bifacial.

Veins vertically transcurrent by sclerenchyma and provided with bundle-sheaths. Tannin sacs absent. Clothing hairs hooked. External glands formed of a stalk-cell and of a globose head. Assimilatory tissue in the axis chlorenchymatous. Pericycle formed of stone-cells. Medullary rays 1-2 seriate. Pith formed of thin-walled cells.

Phaseolus trilobus *Ait.*—Fig. 112. Epidermal cells tabular with inner walls gelatinised. Mesophyll bifacial. Veins vertically transcurrent by collenchyma. Bundle-sheaths absent. Tannin sacs in the palisade tissue. Clothing hairs in the form of uniseriate trichomes with muriculate walls. External glands club-shaped. Assimilatory tissue in the axis chlorenchmatous. Pericycle formed of bast fibres. Medullary rays 1-2 seriate. Pith formed of thin-walled cells.

Rhynchosia arenaria *Blatt. and Hall.*—Figs. 116, 117. Epidermal cells tabular. Mesophyll bifacial. Veins vertically transcurrent by sclerenchyma and provided with bundle-sheaths. Tannin sacs found in the middle of the mesophyll and in soft bast. Clothing hairs in the form of uniseriate trichomes with muriculate walls. External glands consisting of an uniseriate stalk and of a spherial head. Assimilatory tissue in the axis chlorenchymatous. Pericycle formed of stone-cells. Medullary rays 2-3 seriate. Pith formed of thin-walled cells.

Rhyncosia rhombifolia *Blatt. and Hall.*—Figs. 113, 114, 115.

Epidermal cells tabular. Mesophyll bifacial. Veins vertically transcurrent by sclerenchyma and not provided with bundle-sheaths. Tannin sacs found in the middle of the mesophyll and in soft bast. Clothing hairs in the form of uniseriate trichomes with muriculate walls. External glands formed of an uniseriate stalk and of a spherical head. Assimliatory tissue in the axis chlorenchymatous. Pericycle formed of stone-cells. Medullary-rays 2-3 seriate. Pith formed of thick-walled cells.

Structure of the Leaf:—Epidermal cells may be tabular with straight lateral walls, or may be polygonal with lateral walls undulated, as in species of *Crotalaria* fig, 100 and *Heylandia latebrosa* fig. 99. Outer walls are thickened and cuticularised; inner and lateral walls are thin. There are large thin-walled water-storing cells with outer and inner walls convexly arched outwards and inwards respectively, intercalated amongst the ordinary epidermal cells in *C. Burhia* fig. 100 and H. *latebrosa* fig. 99. The toothed condition of the outer walls in A. *vaginalis* may be the result of the arrest of parenchyma owing to the deficiency of water. Papillose differentiation of the outer walls is rare. Inner walls in P. *trilobus* are gelatinised.

Stomata are depressed and are found equally numerous on both the surfaces of the leaf when it is isobilateral, or are more numerous on the lower surface when it is bifacial. Stomata are surrounded by ordinary epidermal cells.

The mesophyll is isobilateral in *C. Burhia* fig. 100, species of *Indigofera* figs. 104, 106 and *P. odorata* fig. 108. It is bifacial in *H. latebrosa*, *C. medicaginea*, *A. vaginalis*, *P. trilobus* and species of *Rhyncosia*. The chief character of the mesophyll is the occurrence of large cells, distinguished by shape and contents in the middle of the mesophyll; they hold tanniniferous contents and are especially prominent in species of *Indigofera* figs. 104, 106, *Tephrosia* and *Rhyncosia*. In species of *Crotalaria*, *Psoralea* and *Alysicarpus* there is a layer of large polygonal cells in the middle, poor in chlorophyll and perhaps occasionally serving as an aqueous tissue. *P. trilobus* does not possess any differentiated layer of cells in the middle of the mesophyll.

The isobilateral arrangement of the palisade tissue is common and spongy parenchyma, when present on the abaxial side, is scantily provided with intercellular spaces. The reduction of the ventilating system in the mesophyll is a proof of the xerophytic nature of the plant.

Internal secretory organs are represented by tannin sacs. They occur in the middle of the mesophyll in *I. cordifolia* and in species of *Tephrosia* and *Rhyncosia* and in the palisade tissue in *I. paucifolia* and *P. trilobus*. In species of *Crotalaria* and *Psoralea* tannin sacs are very few and occur in the neighbourhood of the veins. Tannin sacs are not found in species of *Heylandia* and *Alysicarpus*. Sections of the leaf of *C. medicaginea* were found to be mucilaginous while changing them from lactic acid to glycerine; this may suggest the presence of mucilaginous cells in the mesophyll.

P. odorata is characterised by the occurrence of intercellular secretory receptacles, termed intramural glands. They occur close beneath the epidermis in the palisade tissue and are bounded towards the palisade tissue by a sheath of cells closely fitting together. The space is traversed by a number of narrow tubular secretory cells, curved more or less like meridians. The external walls of these cells are thickened and take part in the formation of the surface of the leaf. Intramural glands are much more numerous on the lower surface than on the upper.

Oxalate of lime is not found in any form in any of the members.

The veins are embedded in species of *Crotalaria* and *Indigofera*; they are vertically transcurrent above and below by means of collenchyma in *P. trilobus*, by selerenchyma in species of *Heylandia*,

Tephrosia, *Alysicarpus* and *Rhyncosia*. The veins are few and do not anastomose freely, which suggests that the leaves do not transpire vigorously.

The hairy covering consists of clothing and glandular hairs. Clothing hairs are of the nature of uniseriate trichomes and have varied forms as follows:—

(*a*) With walls smooth or muriculate as in *H. latebrosa*, *C. Burhia* fig. 100 and species of *Tephrosia*, *Phaseolus* and *Rhyncosia*.

(*b*) Terminal cell bent in the form of a hook in *A. vaginalis* fig. 110.

(*c*) Terminal cell bent and lying parallel to the surface and with a muriculate surface in *P. odorata* fig. 108.

(*d*) Two-armed and formed of a stalk cell and of an unicellular two-armed terminal cell, the arms being equal in species of *Indigofera* fig. 105.

The covering of clothing hairs in isobilateral leaves is not dense and it should be noted that two-armed hairs in *Indigofera*, though few in number, are short-stalked and form a suitable light screen close to the surface of the leaf, against strong light and glare, which accelerates transpiration and is injurious to chlorophyll.

External glands are not found on the leaf of species of *Heylandia*, *Crotalaria*, *Indigofera* and *Tephrosia*. In species of *Rhyncosia* glandular hairs are formed of a short uniseriate stalk and of a spherical head fig. 114; they occur on both the surfaces. External glands in *P. odorata* and *P. trilobus* are club-shaped and consist of a short uniseriate stalk and of a head divided by horizontal and vertical walls. Glandular hairs in *A. vaginalis* are composed of a stalk-cell and a globose head, divided by horizontal and vertical walls; they occur only on the lower surface of the leaf.

It should be observed that external glands are found in a small number of species and sometimes only on the lower surface.

Structure of the Axis:—The epidermis is two-layered in species of *Heylandia*, *Crotalaria* and *Psoralea*; it is single layered in species of *Indigofera*, *Tephrosia*, *Phaseolus*, *Alysicarpus* and *Rhyncosia*. The outer walls are thickened and are arched convexly outwards.

Hairy covering has the same character as of that on the leaf. It should be noted that glandular hairs formed of a multicellular stalk and of an irregularly divided head are found in *I. argentea*.

Internal secretory organs are represented by tannin sacs. They are abundant in species of *Indigofera* and occur in the cortex and pith. Some of the vessels in *I. linifolia* also hold tanniniferous contents. Tannin sacs occur in the soft bast of species of *Psoralea* and *Rhyncosia*.

Primary cortex is characterised by assimilatory tissue and collenchyma. The assimilatory tissue is formed of palisade cells in *C. Burhia;* in others it is chlorenchymatous. The collanchyma is developed in the ribs of the ribbed axis. Ribs are strengthened by sclerenchyma in *I. anabaptista*, *P. odorata* and *P. trilobus*. Cork was not developed in any of the species examined. The endordemis, when differentiated, consists of tabular cells.

The pericycle is composed of a composite ring of bast fibres in species of *Heylandia*, *Indigofera*, *Psoralea* and *Phaseolus*. It forms a composite ring of stone-cells in species of *Crotal aria*, *Tephrosia*, *Alysicarpus* and *Rhyncosia*. In species of *Heylandia* and *Phaseolus* groups of bast fibres are developed along three-fourth of the circumference of the axis, while along the remaining portion the pericycle is parenchymatous. This is curious and suggests that the axes are much inclined and that sclerenchyma is developed only on the upper side of the inclined axis. Small groups of bast fibres occur in soft bast of *Alysicarpus vaginalis.*

The perforations of vessels are simple. Size of lumen, abundance and arrangement of the vessels vary in different genera and even in species. These differences may be useful in diagnosis of genera and species, if due allowance is made for modifications introduced by conditions of the soil.

The vascular system, as a whole, is characterised by the poor development of vessels as regards size and abundance, by abundance of wood prosenchyma and by poorly developed wood parenchyma. These modifications are due to the arrest of the development of parenchyma owing to deficiency of water. A system of well developed water conducting tissue is not required in the axis of desert plants in which all structures are adapted to diminish transpiration. It should be observed that the size and abundance of vessels are usually inversely proportional to each other.

Soft bast usually forms a continuous ring. It is characterised by the occurrence of tannin sacs in species of *Indigofera*, *Psoralea* and *Rhyncosia* and by the presence of small groups of bast fibres in *A. vaginalis.*

Pith consists of thin-walled cells in species of *Heylandia* and *Crotalaria*, *I. linifolia*, *I. argentia*, species of *Tephrosia*, *A. vaginalis*, *P. tribolus* and *R. arenaria;* and is formed of thick-walled and lignified cells in *I. paucifolia*, *I. anabaptista*, *P. odorate* and *R. rhombifolia.* Some of the pith cells in *I. paucifolia* and *I. argentia* hold tanniniferous contents. The pith composed of lignified cells adds to the rigidity afforded by the mechanical tissue; when it is formed of thin-walled cells it may serve occasionally as an aqueous tissue.

Structure of wood :—

Names of Species.	Vessels.		Interfascicular wood prosenchyma			Medulary rays		General Remarks.
	Lumen.	Abundance.	Arrangement.	Abundance.	Lumen.	Size.	Abundance.	
H. latebrosa ...	Large.	Numerous.	Complete rows.	Scanty.	Large.	1 Seriate.	Numerous.	Vessels larger in the lower portion.
C. burhia ...	Small.	Few.	Complete rows.	Extensive.	Small.	,,	Few.	
C. medicaginea ...	Large.	Numerous.	,,	,,	Large.	,,	Numerous.	
I. linifolia ...	,,	,,	,,	Scanty.	Small.	,,	,,	
I. paucifolia ...	Small.	Few.	,,	Extensive.	,,	1-2 Seriate.	Few.	
I. argentea ...	Large.	Numerous.	,,	,,	Large.	1 Seriate.	Numerous.	
I. anabaptista ...	,,	,,	Incomplete rows.	Scanty.	,,	,,	,,	Rows of vessels in groups of 2-4.
P. odorata ...	,,	Few.	Complete.	Extensive.	,,	,,	Few.	Rows of vessels in groups of 3-4.
T. incana ...	,,	,,	Incomplete rows.	Not	Small.	,,	,,	
T. multiflora ...	,,	,,	,,	,,	,,	,,	,,	
A. vaginalis ...	,,	Numerous.	,,	,,	,,	1-2 Seriate.	Numerous.	
P. trilobus ...	,,	Few.	,,	Extensive.	Very large	,,	Few.	
R. rhombifolia ...	,,	,,	Complete.	,,	Small.	2-3 Seriate.	,,	
R. arenaria ...	,,	,,	,,	,,	,,	,,	,,	

Anomolous structures are represented by cortical vascular bundles in C. Burhia, fig. 101.

General Review

Outer walls of the epidermal cells are thickened and cuticularised. Spongy tissue is greatly diminished and the ventilating system is greatly reduced. Water-storing tissue is extensive in the leaf and occurs either in the epidermis or in the palisade tissue, or in the middle of the mesophyll. Tannin sacs are abundant. Secretory cavities are represented by intramural glands in *Psoralea odorata*. Oxalate of lime is not found in the leaf or axis. The system of veins is poorly developed. Clothing hairs are never unicellular; they are uniseriate trichomes, either simple, or hooked, or armed. Glandular hairs are either club-shaped or spherial and are not abundant.

The pericyle forms a composite ring either of groups of bast fibres or of stone-cells. Vessels have simple perforations and are not numerous. Inter fascicular wood prosenchyma is abundantly developed forming the ground work of the vessels. Wood parenchyma is poorly developed. Medullary rays are usually uniseriate and numerous.

The pith consists of thin-walled or thick-walled and lignified cells.

Anomelous structures are represented by cortical vascular bundles in *C. burhia*.

CAESALPINEAE

Cassia obovata, *Collad.*—Figs 118, 119. Epidermal cells with outer walls papillose. Stomata occurring on both the surfaces. Mesophyll isobilateral. Veins embedded. Clothing hairs unicellular. Assimilatory tissue formed of chlorenchyma. Vessels large. Medullary rays uniseriate. Pith formed of cells with thickened and lignified walls.

Structure of the Leaf:—The epidermal cells have outer walls drawn out into large papillage, fig. 118. The stomata are equally numerous on both the surfaces. Guard-cells are situated in the plane of surrounding cells; and the front cavity is placed in a deep depression formed by the outer papillose epidermal walls.

The mesophyll is isobilateral. The palisade tissue on the adaxial side consists of longer cells than those on the lower surface with transversely elongated cells between. The veins are embedded. The large veins are protected above and below by sclerenchyma; the smaller ones have large strands of sclerenchyma only on the lower side.

Hairy covering consists of unicellular curved hairs with perhaps a function of absorbing water. Walls are thin and superficially knobbed. Glandular hairs are not found in the leaf and axis.

Structure of the Axis :—The epidermal cells are small with outer walls thickened and papillose. The primary cortex is formed of chlorenchyma.

The pericycle forms a more or less composite ring of stone-cells. The wood is composite. Vessels are large and few ; they are more abundant in the inner half of the wood. Interfascicular wood prosenchyma is extensive. Wood parenchyma is more abundantly developed than in Papilionaceae and enclose the inner ends of the xylem bundles. The medullary rays are unseriate.

The pith consists of small cells with thickened and lignified walls.

MIMOSEAE

Acacia Senegal, *Willd.*—Figs. 120, 121. Epidermal cells with outer walls thickened and papillose. Stomata occurring on both the surfaces. Mesophyll formed of palisade tissue on the upper side and of arm-palisade tissue on the lower. Tannin sacs present in the leaf and axis. Veins embedded. Clothing hairs unicellular. Cork subepidermal. Pericycle forming a composite ring of stone-cells. Small groups of stone-cells in soft bast. Vessels large. Medullary rays uniseriate. Pith composed of cells with thick and lignified walls.

Structure of the Leaf:—The epidermal cells have outer walls thickened and papillose. Stomata occur on both the surfaces. The guard-cells are situated in the plane of surrounding cells and the front cavity is placed in a depression formed by the papillose outer walls of the epidermal cells.

The mesophyll is composed of 3-4 layers of palisade cells on the adaxial side and of arm-palisade tissue on the abaxial side. The middle tissue consists of a layer of large parenchymatous cells with tanniniferous contents. Internal secretory organs are represented by tannin sacs occurring in the middle of the mesophyll, in cortex and pith.

The veins are embedded. The veins of the mid-rib are protected on the lower side by strands of sclerenchyma.

The hairy covering consists of a few unicellular clothing hairs. Glandular hairs are not found.

Structure of the Axis :—The cortex is characterised by subepidermal cork. Some of the cells of the tanniniferous cortical parenchyma near the pericyclic stone-tissue contain solitary crystals of oxalate of lime.

The pericycle forms a more or less composite ring of stone-cells. Small groups of stone-cells occur in the soft bast. The wood is composite. Vessels are large and are arranged in incomplete rows. Interfascicular wood prosenchyma is extensive and is composed of small thick-walled cells with small lumina. The medullary rays are uniseriate. Wood parenchyma is little developed.

Pith is composed of small cells with thickened and lignified walls.

ROSACEAE

Neurada procumbens *L*.—Figs. 122, 123, 124.—Epidermal cells tabular with outer and inner walls thickened and convexly arched outwards and inwards respectively. Stomata found on both the surfaces and accompanied by ordinary epidermal cells. Hairs uncellular and wooly. External glands absent. Mesophyll composed wholly of short palisade cells. Internal secretory cells with mucilaginous membrances on all sides and occurring near the veins in the leaf, and in collenchyma, cortical parenchyma, medullary rays and pith of the axis. Epidermal cells with tanniniferous contents. Leaves many ribbed. Smaller veins embedded. Larger veins vertically transcurrent by collenchyma. Epidermal cells of the axis with outer-walls papillose. Medullary rays broad. Interfascicular wood prosenchyma absent. Pith composed of thin-walled cells. Pith cells with mucilaginous walls towards the periphery.

Structure of the Leaf:— The epidermis consists of tabular cells with outer and inner walls convexly arched outwards and inwards respectively. Lateral walls are thin and straight. Epidermal cells hold tanniniferous contents. The stomata are more numerous on the lower surface and are surrounded by ordinary epidermal cells. The guard-cells are situated in the plane of surrounding cells and the front cavity is placed in a depression formed by the outer thickened epidermal walls fig. 123. The stomata on the axis are similar to those on the leaf.

The mesophyll is wholly composed of short palisade cells fig. 122. Internal secretory organs are represented by cells with mucilaginous membranes on all sides and by epidermal cells of the leaf with tanniniferous contents. Cells with mucilaginous membranes occur near the veins, at the inner margin of cortex, in the medullary rays and in the pith tissue towards the periphery. Tanniniferous contents in the epidermal cells of the leaf give an acrid taste to foliage leaves and prevent them from being easily devoured by animals.

Oxalate of lime is found in the form of numerous small clustered crystals near the veins of the leaf and in collenchyma and soft bast of the axis. The leaves are many ribbed, the ribs being prominent

beneath and grooved above. The smaller veins are enclosed in a sheath of cells, some with mucilaginous membranes and others with clustered crystals. The larger veins are vertically transcurrent above by collenchyma.

The hairy covering is dense and consists of clothing hairs on the leaf and axis. The clothing hairs are unicellular, long and woolly figs. 122, 124 ; they are more numerous on the lower surface of the leaf.

Structure of the Axis :—The epidermis consists of polygonal cells with outer walls thickened and papillose. The inner walls are thickened ; the lateral walls are thin and undulated.

The cortex fig. 124 is composed of collenchyma on the outer side and of an extensive tissue of thin-walled colourless cells on the inner side with perhaps occasionally a water-storing function. Cells at the inner margin of the cortex have mucilaginous membranes.

Sclerenchymatous pericycle is not developed. The wood is composed of large xylem bundles separated by broad medullary rays some of the cells of which have mucilaginous membranes. Interfascicular wood prosenchyma is not developed.

The pith cells towards the periphery are mucilaginous.

LYTHRACEAE

Ammania baccifera *L.*—Fig. 125. Epidermis formed of thin-walled tabular cells. Clothing hairs absent. Oxalate of lime not found. Pericycle formed of bast fibres, with thin walls and large lumina. Small groups of thick-walled cells found in the pith formed of thin-walled cells.

Ammania desertorum *Blatt. & Hall.*—Fig. 126. Epidermal cells tabular with outer walls thickened and convexly arched outwards. Clustered crystalls found near the veins. Conical unicellular hairs with verrucose walls occurring on the axis and on the upper surface of the leaf. Pericycle formed of bast fibres with thick walls and with small lumina. Pith composed of thin-walled cells.

Structure of the Leaf :—The epidermal cells in *A. baccifera* fig. 125 are tabular and thin-walled except at the margin where the outer walls are thickened and convexly arched outwards. In *A. desertorum* the epidermal cells have the outer walls thickened and convexly arched outwards. The cuticle is striated. The lateral walls are thin and straight. The margins are curved downwards.

Stomata are more numerous on the lower surface and are surrounded by ordinary epidermal cells. Guard-cells are elevated and the front cavity is on a level with the surface figs. 125, 126. The stomata on the axis are similar to those on the leaf.

(*To be continued.*)

Plate XIII

105. *Indigofera cordifolia.*
Hair on the leaf.
Oc. 6 Com.; Ob. 8 mm. Ap.

106-107. *Indigofera paucifolia.*
106. T. S. of the leaf.
Oc. 2 Com.; Ob. 3 mm. Ap.
107. T. S. of the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.

108. *Psoralea odorata.*
T. S. of the leaf.
Oc. 4 Com.; Ob. 8 mm. Ap.

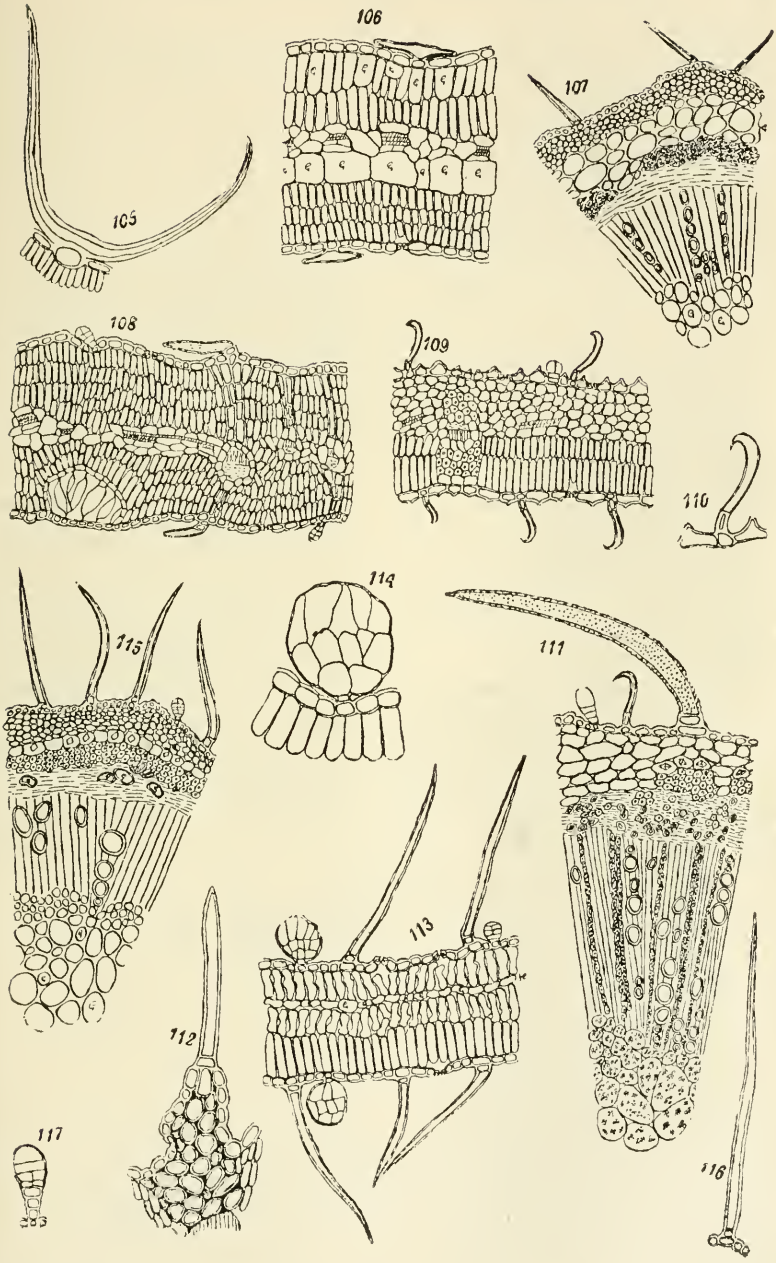
109-111. *Alysicarpus vaginalis.*
109. T. S. of the leaf.
Oc. 6 Com.; Ob. 8 mm. Ap.
110. Hair on the leaf.
Oc. 4 Com.; Ob. 3 mm. Ap.
111. T. S. of the axis.
Oc. 6 Com.; Ob. 8 mm. Ap.

112. *Phaseolus trilobus.*
Hair on the upper side of the mid-rib of the leaf.
Oc. 4 Com.; Ob. 8 mm. Ap.

113-115. *Rhyncosia rhombifolia.*
113. T. S. of the leaf.
Oc. 6 Com.; Ob. 8 mm. Ap.
114. Glandular hair on the leaf.
Oc. 6. Com.; Ob. 3 mm. Ap.
115. T. S. of the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.

116-117. *Rhyncosia arenaria.*
116. Hair on the leaf.
Oc. 6 Com.; Ob. 8 mm. Ap.
117. Glandular hair on the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.

N.B.—To get the original dimensions multiply by 1·7.

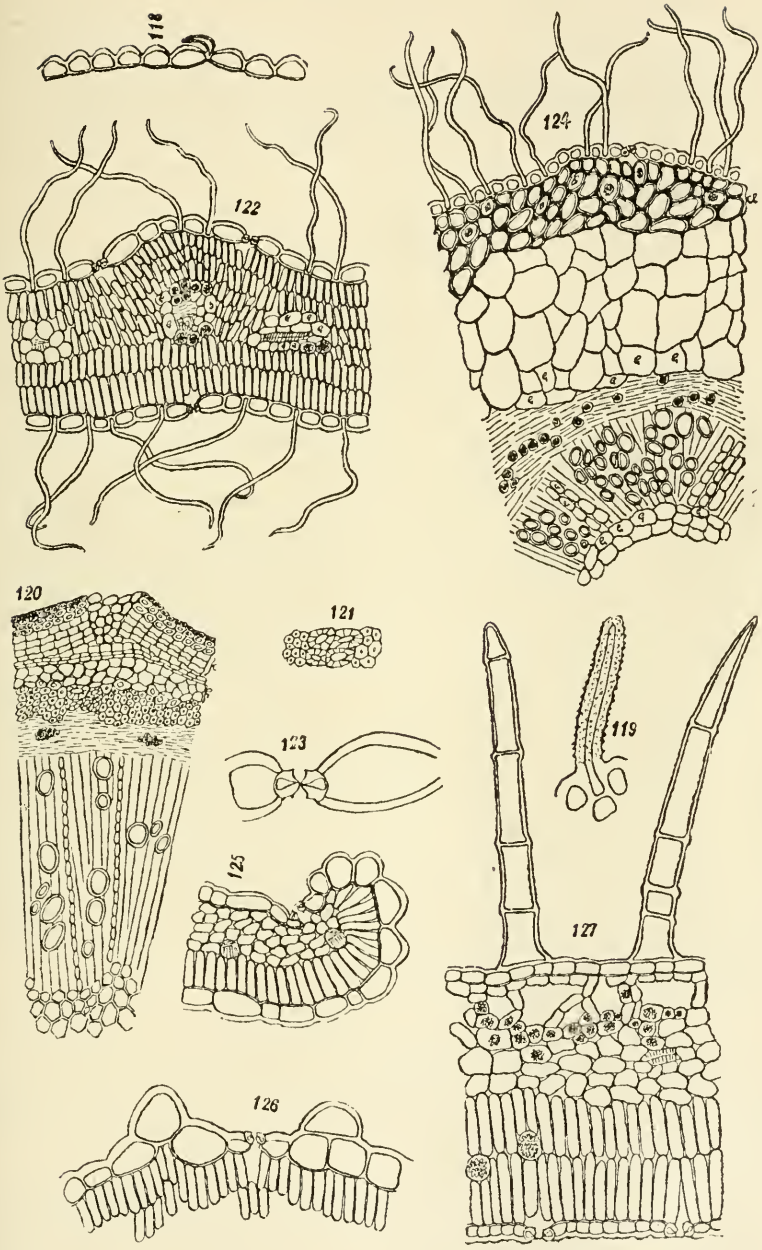


T. S. Sabnis del. PLATE XIII.

Plate XIV

118-119. *Cassia obovata.*
118. T. S. of the leaf showing epidermis.
Oc. 6 Com.; Ob. 8 mm. Ap.
119. Hair on the axis.
Oc. 6 Com.; Ob. 3 mm. Ap.
120-121. *Acacia Senegal.*
120. T. S. of the axis.
Oc. 6 Com.; Ob. 8 mm. Ap.
121. T. S. of the axis showing sclereids between the pericyclic stone cell groups.
Oc. 8 Com.; Ob. 8 mm. Ap.
122-124. *Neurada procumbens.*
122. T. S. of the leaf.
Oc. 4 Com.; Ob. 8 mm. Ap.
123. Stoma on the leaf.
Oc. 6 Com.; Ob. 3 mm. Ap.
124. T. S. of the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.
125. *Ammania baccifera.*
T. S. of the leaf.
Oc. 6 Com.; Ob. 8 mm. Ap.
126. *Ammania desertorum.*
T. S. of the leaf showing epidermis.
Oc. 6 Com.; Ob. 8 mm. Ap.
127. *Trapa bispinosa.*
T. S. of the leaf.
Oc. 4 Com.; Ob. 3 mm. Ap.

N.B.—To get the original dimensions multiply by 1·7.



T. S. Sabnis del PLATE XIV.

NOTE ON THE FLOATING ISLANDS OF RIWALSAR.

BY

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In July 1916, Marietta Pallis published an interesting paper on "The Structure and History of Plav: the floating fen of the Danube" in the Journal of the Linnean Society (Vol. XLIII, No. 291). I believe it is not generally known among botanists that a similar floating fen on a small scale occurs in the Outer Himalayas in Mandi State. The writer had an occasion to visit the place in August 1919 and though it was not unfortunately possible to undertake a detailed investigation of the floating islands or to make a large collection of plants, some interesting observations were however made. This note has been written with a view to induce somebody else with a better opportunity to investigate the place in greater detail.

The islands as stated above are met with in Mandi State in the freshwater lake at Riwalsar, which is for this reason held sacred by the Hindus and the Tibetans (Buddhists) for whom it is an important place of pilgrimage. The lake lies about 10 miles south-west of Mandi, surrounded by hills and some 5,000 feet above sea-level. The Mandi State Gazetteer says practically nothing about the fen. The only information given there in connection with this paper is:—"The circumference of the lake exceeds a mile and its waters are of immense depth. There are many large floating islands on its surface and this singular fact is attributed to its sancity."

No data are available as to the exact depth of the lake, its circumference or the exact size of the islands.

The first point of botanical interest is that the floating islands are formed by *Phragmites* like the Plav mentioned above. A few other plants are also met with in addition but they do not contribute much to the formation of the islands.

The total number of the islands is seven. The largest (known as Parbati's island) is, as seen from a distance, of a few yards about 20 yards long and about 4 yards wide and has rounded ends. The others are much smaller. The islands are formed practically wholly by a species of *Phragmites*, apparently *P. communis*, which forms very

tall clusters. One of the islands (known as Brahma's) has a small willow tree growing on it. It had another shrub also which looked like a rose and the writer was told that it was a rose. This island also bore a flag on a tall pole placed their by the Brahmans. The only other prominent plant on the islands was an aroid which could not be identified further.

All along the margins of the lake the ground at the time of the visit, the rainy season was very swampy. The aquatic plants growing on the bank of the lake were chiefly the following :—Some grasses and sedges, including *Phragmites ;* a *Nymphaea*, a *Trapa*, *Polygonum barbatum*, a *Ceratophyllum*, a *Lemna* and an *Azolla*.

It may be mentioned that the islands move by the action of the breeze, the reeds acting as sails, though the Brahmans there believe in their supernatural and independent movement.

I was told that the level of the lake rises slightly during the rains, but the lake has a permanent supply of water from a subterranean spring and there is a permanent outlet also.

No boats are available at Riwalsar and everything necessary for the investigation should be arranged for beforehand.

THE VASCULAR CONNECTIONS AND THE STRUCTURE OF THE TENDRILS IN SOME CUCURBITACEAE

By Kali Das Sawhney, M.Sc.

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During 1917 and 1918 the writer investigated the anatomy of a number of cultivated species belonging to the Cucurbitaceæ. A few writers have already dealt with the subject, and special mention must be made of Tondera (4) who has carefully investigated the vascular connections of a number of species of this family, and Muller (3) who has worked out the anatomy of the tendrils. The writer has re-examined some of the species worked out by these writers. Their results have been confirmed in a general way. Since however these two papers are not easily available to the ordinary reader and many species investigated by the writer have not been investigated by these writers and in view especially of some interesting results obtained, it is proposed to give a brief summary of the results arrived at by the writer.

It is well-known that the vascular bundles in the stems of the Cucurbitaceæ are generally arranged in two rings of five bundles each. The bundles are usually known as bicollateral as they possess phloem towards the inside of the xylem in addition to the external phloem. The bundles of the inner ring are as a whole larger than the outer bundles. These facts should be borne in mind in the following description unless otherwise stated.

Another point to be remembered is the position of the various organs at a node near the leaf-axil. Usually a number of structures are met with there arranged in a transverse row. In *Benincasa cerifera*, for example, in a ground plan of the node, beginning from the left, we found the following:—a tendril, a vegetative bud, a flower, a glandular structure looking like a rudimentary leaf. The last structure is absent in some species, and has a different form in some others. These differences would be indicated at the proper places.

Methods

In addition to free-hand sections other methods were also employed in the investigation. In some cases complete series of

sections were prepared through the nodes to study the course of the vascular bundles. In other pieces of stem were macerated in a suitable medium. In some cases both methods were tried.

A few words may be said about maceration. Several chemical reagents were tried, but none was found satisfactory. Even boiling in tap water was found too drastic. Ultimately the pieces of stems with their attached organs were left in ordinary tap-water for a number of days—about five in summer and about ten in winter—and then the vascular skeleton was prepared by teasing out the softer tissues.

The following species were studied. The methods adopted are also indicated.

1. **Benincasa cerifera** *Savi.* Maceration.
2. **Lagenaria vulgaris** *Seringe.* Maceration.
3. **Citrullus vulgaris** *Schrad.* Free-hand sections.
4. **Trichosanthes anguina** *Linn.* Serial sectioning.
5. **Trichosanthes dioica** *Roxb.* Maceration.
6. **Luffa acutangula** *Roxb.* Serial sectioning and maceration.
7. **Luffa pentandra** *Roxb.* Maceration.
8. **Cucumis melo** *Linn.* Serial sectioning and maceration.
9. **Cucumis momordica** *Roxb.* Free-hand sections.
10. **Momordica echinata** *Linn.* Serial sectioning and maceration.
11. **Momordica charantia** *Linn.* Serial sectioning.
12. **Cucurbita maxima** *Duchesne.* Maceration.

Of these species Tondera has figured the vascular connections of 1, 2 and 8; while Muller has figured the tendril-anatomy of No. 4.

After this preliminary account we may pass on to the details in the species investigated.

Benincasa cerifera.

In the axil [1] of the leaf we find a row of four different organs. From the left, we have a two-armed tendril, a vegetative bud which sometimes developes into a shoot, a flower and lastly a glandular structure standing erect and with margins rolled inwards, resembling a rudimentary leaf. (Fig. 1.)

The stem is five-angled as usual in the family. In mature specimens the inner and the outer rings of vascular bundles are very near each other and very nearly merge into one ring. (Fig. 2)

[1] None of these structures is really axillary. In the Cucurbitaceæ most of the structures occurring at this place are extra-axillary. The word is used merely for the sake of convenience throughout the paper.

The leaf-stalk is dorsiventral in its organisation, markedly so in its upper part where it has a distinct groove on its adaxial side. The number of vascular bundles varies from nine to eleven, those nearest the groove being the smallest. (Fig. 3)

The basal part of the tendril is radial in section, the number of bundles various from six at the lower to ten in the upper part, and they are as a rule arranged in one ring. There is absolutely no trace of a ventral groove as is present in the petiole. (Fig. 4)

Both the branches of the tendril show a dorsiventral structure with a distinct groove on the apparently upper surface. The vascular bundles are five in number in the form of an arc open above as seen in a transverse section. (Fig. 5)

The vascular connections at the node are as follows :—The traces from the tendril, the vegetative bud and the flower-stalk all pass through the cortex and join the bundles of the inner ring. The leaf-stalk sends three traces into the cortex. Of these, one (median) passes down the internode below without anastomosing with any bundle at the node; the two lateral traces join the two adjacent bundles of the outer ring, each with the one on its own side. One bundle of the inner ring, while coming from the upper internode, gradually decreases in size and ultimately ends blindly immediately above the node or just reaches it. The bundles of the inner ring anastomose at the node and this ring receives a bundle from the outer ring also to take the place of the one that has just ceased at each node. Thus at every node one bundle of the inner ring stops and a bundle from the outer ring joins the inner ring to take its place[1] while the place of the latter is taken by the median leaf-trace which passes down the lower internode without anastomosing. The gradual decrease in size of one of the bundles of the inner ring at each internode, as described above, is the cause of the dorsiventrality of the arrangement of the vascular bundles common in the family. (3)

It is clear from the above description that the bundles of the outer ring are really continuations of the leaf-traces, while the bundles of the inner ring are mainly cauline.

Lagenaria vulgaris.

The organs at the node beginning from the left are, a branched tendril with five arms very close to each other, a bud and a flower. The glandular organ is missing.

The vascular structure of the stem and the leaf-stalk is in general the same as in *Benincasa cerifera*.

[1] This new inner bundle is not, however, a direct continuation of the outer bundle.

The basal part of the tendril is radial in section and has a ring (as seen in t. s.) of six to nine bundles which anastomose at different levels.

The arms of the tendrils are similar in structure to those of *Benincasa cerifera*.

The vascular connections of the tendril and the leaf with the stem are also similar.

Citrullus vulgaris.

The arrangement of organs at the node is similar to that in *Benincasa*, except that the flower is here replaced by an inflorescence. The tendril is two-armed.

The stem and leaf-stalk do not present any great differences from the first type.

The basal part of the tendril is radial with nine to twelve or thirteen bundles which are so arranged that large and small bundles alternate. The branches of the tendrils show the same structure as in the first type except that the bundles are seven at the base diminishing to five near the apex.

Trichosanthes anguina.

The relationships of the organs at the node are the same as in *Benincasa cerfera* but the tendrils are four-armed.

The structure of the stem and the petiole is in general similar to that of the first type.

The basal part of the tendril in transverse section is slightly six-lobed and has six bundles in one ring. There is no trace of a ventral groove so that the structure is radial. The tendril-arms have a distinct groove and the bundles are arranged on the type of the petiole.

The vascular bundles of the tendril unite with the bundles of the inner ring of the stem, while the leaf-traces are connected with the outer bundles as described before.

Each tendril-arm receives three branches from three bundles of the tendril situated on the side on which the arm is given off.

In one case it was found that a ripe elongated fruit was apparently arising immediately below the branching point of a tendril. On cutting sections of the lower part of the tendril it was found that it was merely a case of fusion of the flower-pedicel with the basal part of the tendril. Goebel mentions a simlar case.

Trichosanthes dioica.

The arrangement of the organs at the node is the same as in the last species but the tendrils are simple.

The structure of the stem and the petiole is of the usual type. The structure of the tendril however is dorsiventral throughout its entire length. At the base there are seven vasculer bundles which are reduced to five in the upper part. The traces of the tendril join the inner bundles of the stem just like the traces of the branched tendrils of other species. The middle leaf-trace passes straight down without anstomosing, while the lateral leaf-traces join the adjacent bundles of the outer ring of the stem.

LUFFA ACUTANGULA.

The arrangment of the organs at the node is as in Benincasa. The tendriis are four-armed, the branches arising along a very compact spiral.

The structure of the stem, petiole and the base of the tendril is similar to that in *Benincasa cerifera*.

The main arm of the tendril, the one which is in continuation of the basal part, has a structure similar to that of the basal part. The other arms have a petiole-like type of structure, having a distinct groove along the ventral side and horse-shoe arrangement of bundles.

The vascular connections of the various organs with the stem bundles are similar to those of *Benincasa cerifera*.

LUFFA PENTANDRA.

The arrangement of the organs at the node is as follows a four-armed tendril, a bud, an inflorescence and a triangular leaf-like appendage bearing several circular facets.

The structure of the stem, petiole, the base of the tendril and the tendril-arms is similar to that of the corresponding organs in *Benincasa cerifera*. The vascular connections are also similar.

CUCUMIS MELO.

The disposition of the organs at the node is as usual. The glandular organ is a circular faceted structure. The tendrils are simple.

The stem and the petiole do not show any unusual feature in their structure.

The tendril is dorsiventral throughout its entire length as shown by the presence of the groove and the horse-shoe arrangement of the bundles.

The vascular connections of the tendril-traces and the leaf-traces are the same has described for *Benincasa cerifera*.

CUCUMIS MOMORDICA.

The disposition of the organs at the node and the internal structure of the various organs is in general similar to that in the last species.

Momordica echinata.

Both simple and branched two-armed tendrils are found on the same plant. The disposition of the nodal organs is as in *Citrullus vulgaris* except that the leaf-like appendage is absent.

The stem and the petiole show the usual structure, the latter with only seven vascular bundles.

The base of the tendril, both in branched and unbranched specimens is four-lobed and has four bundles only. The arms in the case of the branched tendrils, and the upper portion of the tendril in the case of the simple ones, possess a dorsiventral outline showing a distinct ventral groove and five bundles arranged in a horse-shoe manner.

The vascular connections are like those of *Luffa acutangula* and the rest, already described or to be described later.

Momordica charantia.

Tendrils are all simple. To the right of the tendril at the node is a vegetative bud and next to this a flower. The glandular organ is absent.

The stem and the petiole has the usual structure.

The base of the tendril is four-lobed as in *Momordica echinata*. It has four bundles. One of them divides into two a little higher up and the tendril at the same time develops a groove, thus becoming petiole-like in its organisation.

The bundles of the tendril anastomose with the bundles of the inner ring of the stem.

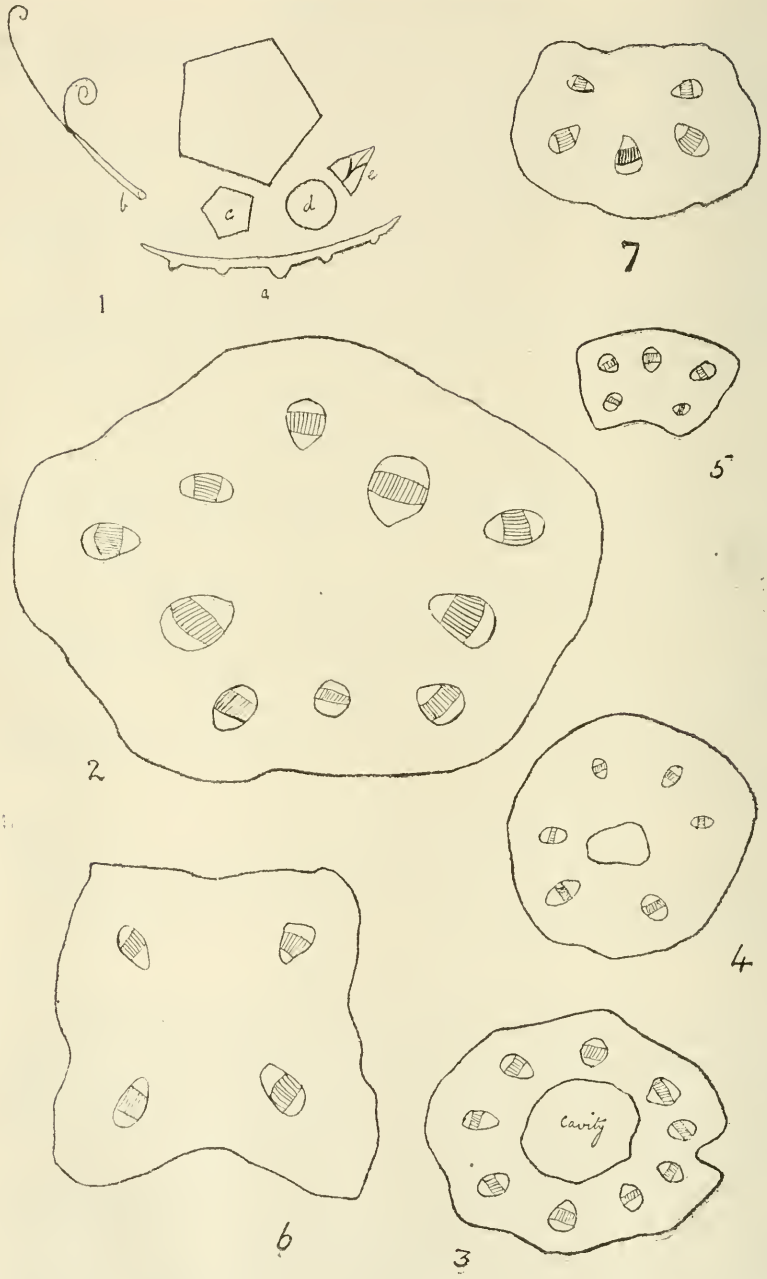
Cucurbita maxima.

The tendrils in this species are four or five-armed. The vascular connections of the leaf-traces and the tendril-traces are the same as described for *Benincasa cerifera*.

Concluding remarks

It will be seen from what has been described before that or of the twelve species examined, four, *i.e.*, *Cucumis melo*, *Cucumis momordica*, *Trichosanthes dioica and Momordica charantia*, have simple tendrils; *Momordica echinata* has both simple and branched tendrils; while all the rest, have branched tendrils.

The vascular connections of the stem with the tendril, the flower, the vegetative bud and the leaf have been examined in all except *Citrullus vulgaris*. The structure of the leaf-stalk and the tendrils at various levels has been examined in all except *Cucurbita maxima*.


b
c
d
e
a
1
7
5
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6
cavity
3

The results are as follows:—

1. The vascular bundles from the flower, the vegetative bud and the tendril (whether simple or branched) in all the species examined unite with bundles of the inner ring of the stem at the node at which these organs arise.

2. Three bundles enter the stem from the leaf-stalk. The median passes straight down through the internode without uniting with any other bundle. The two lateral bundles unite with the adjacent bundles of the outer ring of the stem, one on each side.

3. At each node one of the bundles of the inner ring stops and its place is taken by a bundle from the outer ring. The bundles of the inner ring anastomose at the nodes.

4. The base of the tendril in all species with branched tendrils is organised radially the bundles being arranged in a ring and there being no groove, such as is present in the petiole. This is also true of the simple tendrils of *Momordica echinata*.

5. The tendrils in all the species with simple tendrils except *Momordica charantia* are organised on the type of the petiole with horse-shoe arrangement of bundles and a groove on one side throughout their entire length. In *Momordica charantia* the tendril is radially organised at the base and dorsiventrally above.

6. In all species the upper part of the simple tendrils and the arms of the branched tendrils throughout their entire length are organised on the type of the petiole. The main arm of the tendril which is a continuation of the basal part in *Luffa pentandra* is, however, radially organised. The upper part of this arm was unfortunately not examined. It would probably possess a dorsiventral structure.

The following conclusions are drawn from the above results:—

1. The vascular connections and the structure of the basal part of the branched tendrils show that they are homologous with the ordinary shoots.

2. The arms of the branched tendrils and the upper part of the simple tendrils are homologous with the ordinary leaves.

3. The simple tendrils have been derived from the branched tendrils and therefore homologous with them. Species of *Momordica* show the transition in *M. echinata* possessing both simple and branched tendrils and in *M. charantia* possessing only simple tendrils the base of the tendril is always radially organised. In other species with simple tendrils the modifications has gone still further and even the basal part has become petiole-like.

It may be stated that conclusions one and two are in general agreement with the conclusions of Muller and Tondera, but according

to Goebel (1) the simple tendrils are modified prophylls while a branched tendril represents a prophyll adherent to an axillary shoot.

My thanks are due to Professor S. R. Kashyap for much suggestive criticism and other help in the preparation of this paper. The work was done under his supervision in the Government College Biological Laboratory before the writer joined the Islamia College, Peshawar.

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Explanation of figures. (1-5, Benincasa cerifera; 6-7, Momordica echinata.) xylem is shaded throughout.

1. Disposition of organs at the node. a, leaf; b, tendril; c, vegetabud; d, flower; e, glandular organ.
2. Transverse section of steam in outline.
3. Transverse section of petiole in outline.
4. Transverse section of the base of a tendril in outline.
5. Transverse section of an arm of a tendril.
6. T. S. of the vase of the tendril.
7. T. S. of an arm of a tendril

CONTRIBUTIONS TOWARDS A FLORA OF BALUCHISTAN

From materials supplied by Col. J. E. B. Hotson, I.A.R.O

BY

E. Blatter, S. J., Prof. F. Hallberg and C. McCann.

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(*Continued from last issue*)

Plantaginaceae.

Plantago *L.*

Plantago maior, *L. Sp. Pl. (1753)* 112.—Loc.: Khudabadan, ¼ mile N. of Panjgur about 3,000 ft.; jerri, 147 miles SSW of Kalat, 3,800 ft. (no. 222).—Fr. in Aug. 1917.

Vern. Name: Khari Gosh (Bal.).

Plantago maior, *L.* var. **minor** *Boiss.*—Loc.: Spring on Harboi, 18 miles to SE of Kalat, 8,600 ft. (no. 68); Iskalku, 7 miles S. of Kalat, 7,500 ft. (no. 90).—Fl. in Aug. 1917.

Uses: Eaten by " gad " (Hotson).

Plantago lanceolata, *L. Sp. Pl. 113.*—Loc.: Khozdar. 27°, 48′ N, 66° 371 E, about 4,100 ft. (no. 344); Surab (Jhalarwan), 28° 29′ N, 66° 16′ E, about 5,700 ft (no. M 378); Panjgur about 3,100 ft. (no. M 156).—Fl. and fr. in March and June 1918, Sept. 1917.

Vern. Name: Danichk (Bal. Br.), Barz (Br.), Aspangara (Urdu, Sind.).

Plantago lagocephala *Bunge in Mem. Sav. Etr. Petersb. VII (851) 445.*—Loc.: Dokop, 10½ miles E. of Mand, about 650 ft. (no. M 68), Rek Chah, 11 miles E. of Chambar, Kolwa, about 1,800 ft. (no.M 271). —Fl. and fr. in March and April 1918.

Uses: Various preparations are used against gripes, constipation, white " urine, " and boils.

Vern. Name: Danishk (Bal.), Pidarri (Br.), Isufgol (? Urdu).

Plantago psyllium *L. Sp. Pl. 115*—Loc. Garmkan, 1 mile NE of Panjgur about 3,135 ft. (no. M162).—Fr. in March 1918.

Plantago ciliata, *Desf. Fl. Atl. I 137, t. 39, var. lanata* Boiss.—Loc.: Kharan about 3,600 ft. (no. 303).—Fr. in April 1918.

Vern. Name: Naren Danichk (Bal.).

Plantago sp.—Loc.: Spring on Harboi, 18 miles ESE of Kalat, 8,600 ft. (no. 70); Surab (Jhalarwan), 28° 29′ N, 66° 16′ E, about 5,700 ft. (no. M 378A).—Fl. in June 1918, fr. in June 1918, Aug. 1917.

Vern, Name: Barz, Mashana Choteli (Br.),

Nyctaginaceae

Boerhaavia *L.*

Boerhaavia elegans *Chois. in. DC. Prodr. XIII, 453.*—Loc.: Hodal Pass, about 85 miles S of Panjgur, 2,900 to 3,400 ft. (no, M 255), Mandi Parag, about 22 miles E of Chambar (Kolwa). about 1,900 ft. (no. M 275; Gwambuk, about 69 miles SE of Panjgur, about 2,700 ft. (no. M 208); Rari Dan, 175 miles SW of Kalat, 2,300 ft. (no. 285).

Vern. Name: Askkah Kohi Pindal (Bal.), Roding Babi (Br.).

Boerhaavia plumbaginea *Cay. I, II, 7, tab. 112.*—Loc.: Chhuttok, 90 miles S. of Kalat, 4,500 ft. (no. 117).

Boerhaavia diffusa *L. Sp. Pl. (1753) 3.*—Loc.: Rari Dan, 175 miles SW of Kalat, 2,300 ft. (no. 219 A); Rar Kaur, 165 miles SW of Kalat, about 3,500 ft. (no .219 B); W side of Burida Pass, 140 miles SSW of Kalat, under 4,250 ft. (no. 219); Gwambuk, about 60 miles SE of Panjgur, about 2,700 ft. (no. M 208A).—Fl. in April 1918, Aug. 1917. Fr. in. Sept. 1917.

Vern. Name : Saring (Bal.).

Boerhaavia verticillata *Poir. Encycl. Meth. V (1804)* 56.—Loc.: Near Manguli, 197 miles SSW of Kalat, about 2,450 ft. (no. 246); Pirandar, 205 miles SSW of Kalat, about 1,900 ft. (no. 261).—Fl. in Sept. 1917.

Vern. Name: Wal (Bal. and Br).

Illecebraceae

Gymnocarpos *Forsk.*

Gymnocarpos decandrum *Forsk. Fl. Aeg. Arab. 65 (1775).*—Loc.: Rari Dan, 170 miles SW of Kalat, 2,300 ft. (no. 289); Tapk, about 62° 50′ E, 26° 19′ N, about 1,750 ft. (no. M34A); NE of Hoshap, about 60 miles ENE of Turbat, about 2,000 ft. (no. M34).—Fl. in Sept. 1917. Fr. in March 1918.

Vern. Name: Mazhong (Bal. and Br.), Zafti (Br).

Amarantaceae

Digera *Forsk.*

Digera arvensis Forsk. *Fl. Aeg Arab. 65.*—Loc.: Ornach, 380 ft. (no. 183A). Fl in Sept. 1917.

Vern Name: Maliro (Br. Bal.).

Amarantus *L.*

Amarantus paniculatus *L. Sp. Pl. ed. 2, 1406.*— Loc.; Surab, 43 miles S. of Kolat, 5,750 ft. (no. 110).—Fr. Aug. 1917.

Amarantus gangeticus *L. Syst. Nat. ed. 10 (1759) 1268.*— Loc.: Korak (Pelar), 130 miles S. by W. of Kalat, 1,900 ft. (no 227); Teghab, 107 miles S of Kalat, 4,150 ft. (no. 183).— Fl. and fr. in Aug. and Sept. 1907.

Vern. Name: Maliro (Bal. and Br.).

AERUA *Forsk.*

Aerua tomentosa *Forsk. Fl. Aeg. Arab. CXXII and 170.*—Loc.: Near Kuldan (W. Kolwa), about 85 miles E. by. N. of Turbat, about 2,400 ft. (no.M135B); Gwambuk, about 60 miles SE of Panjgur, about 2,700 ft. (no.M209): Burida Pass, 140 miles SSW of Kalat up to 4,250 ft. (no. 213); Awaran, Kolwa, 26° 24′ N, 65° 12′ E, about 1,750 ft. (no.M282) Zahrin, Kahur, 16 miles N of Pasni about 200 ft. (no.M45); Las Bela, about 700 ft. (no. 213A); near Ornach, about 3,300 ft. (no. 314).— Fl. and fr. in Aug. and Oct. 1917.

Uses: The flowers when fully developed are dried and used for stuffing cushions (Hotson).

Vern. Names: alisht Bur, Isped Phul (Br. and Bal.), Pihunpulli (Br.), Kirech (Bal.), Buh (Lassi Sindhi).

ACHYRANTHES *L.*

Achyranthes aspera *L. Sp. Pl. 204.*— Loc: Dalnakher, 29 miles N. of Las Bela, about 2,000 ft. (no. 396); Jebri, 147 miles SSW of Kalat. 3,850 ft. (no. 232); Khozdar, 27° 48′ N, 66° 37′ E, about 4,100 ft, (no. 351).—Fl. and fr. in Aug., Sept. and Oct. 1917.

Vern. Name: Khari Gosh = Donkey's Ear (Bal.).

Chenopodiaceae.

CHENOPODIUM *L.*

Chenopodium album *L. Sp. Pl. 219.*—Loc. Panjgur, about 3,100 ft. (M175). Fl. and fr. in March 1918.

Uses: Eaten as a vegetable.

Vern. Name: Batu (Sind.).

Chenopodium opulifolium *Schrad. in DC. Fl. Franc. V. 372.*— Loc.: Panjgur (no.M324).; Manguli (Jhalarwan), 26° 44′ N, 65° 22′ E., about 2,600 ft. (no.M298); near Iskalku, 7 miles E. of Kalat, 7,500 ft. (no. 91); Kalat, about 6,350 ft. (no. M398).— Fl. and fr. from April to Aug. 1918.

Vern. Name: Mariro (Br.), Lularo (Bal.).

Chenopodium hybridum *Sp. Pl. 219.*—Loc: Awaran Fort, 4 miles N. of Rekin, Kolwa, about 1 800 ft. (M245A); Harboi, 18 miles ESE of Kalat, 9,000 ft, (No. 77),— Fl. and fr. in April 1918 and Aug. 1917.

Uses: It is said that men eat the leaves.

Vern. Name: Kodalo (Bal.), Sirech (Br.).

Chenopodium murale *L. Sp. Pl. 219.*—Panjgur, about 3,200 ft. (no. M172); Turbat, 66° 4′ E, 25° 58′ N, about 600 ft. (no.M56).—Fl. and fr. in Feb. and March 1918.

Vern. Name: Kulpir (Bal.?), Lalor (Sind).

BETA *L.*

Beta vulgaris *L. Sp. Pl. 222.*—Loc. Panjgur (no. M323).—Fr. in May 1918.

ATRIPLEX *L.*

Atriplex repens *Roth Nov. Sp. 377.*—Loc.: Panjgur (no. M148B); Khudabadan ¼ mile N of Panjgur, about 3,100 ft. (no. M148A); Sitani (Gidar), 59 miles S. of Kalat, 5,300 ft. (no. 117); Garrok (no. 325).—Fl. and fr. in May 1918, Aug. and Sept. 1917.

Vern. Name: Sorinchk (Bal.), Surinchk (Sarawan Br.), Gwaja (Jhalarwan Br.).

Atriplex Griffithi *Moq. in DC. Prodr. XIII, II, 102.*—Loc.: Harbud, about 50 miles E. of Panjgur, about 3,700 ft. (no. M313).

Uses: Said to be eatable.

Vern. Name: Magir (Br.).

KOCHIA *Roth.*

Kochia odontoptera *Schrenk in Bull. Acad. Petersb. I (1843) 361.*—Loc.: Panjgur, about 9,100 ft. (no. M174).

Vern. Name. Sorag (Bal.?).

Kochia sedo des *Schrad. Neues Journ. III (1809) III & IV, 85.*—Loc.: Kalat, 7,000 ft. (no. 1).

Uses Used as a medicine for worms. It is crushed in cold water and allowed to stand over night, and swallowed in the morning with some sweetmeat. (Hotson).

Vern. Name: Khisunshir. (Br.).

SUAEDA *Forsk.*

Suaeda nudiflora *Moq. in Ann. Sc. Nat. ser. XXIII, 316.*—Loc. Zahrenkahur 16 miles N of Pasni, about 200 ft. (no. M5B); Nodiz, 20½ miles W. of Turbat about 400 ft. (no. M5A); near Kalatak, 12 miles W. of Turbat, about 8,000 ft. (no. M5) Mazarjuh (Gidar, Jhalarwan), 28° 11′ N, 66° 2′ E. about 5,200 ft. (no. M5C); near Bazdad, about 25 miles E of Chamba (Kolwa), about 1,850 ft. (no. M5 cbis).

Vern. Name: Rigit (Bal. Br.).

Suaeda monoica *Forsk. Fl. Aeg. Arab. 70.*—Loc.: Las Bela, about 700 ft. (no. 164C); 27 miles N. of Ornach, about 3,400. (no. 188A); Teghab, 107 miles S. of Kalat, about 4,150 ft. (no. 188).

Vern. Name: Trat, Lana; Right (Bal., Br.).

Suaeda physophora *Pall. III. 55, tab.* 43.—Loc.: NE of Hoshap, about 60 miles ENE of Turbat 2,000 ft. (no. M32); Gwambuk, about 50 miles SE of Panjgur, about 2,700 ft. (no. M26).—Uses: Good sheep-grazing.

Vern. Name: Sorag, Lundo (Bal.).

HALOXYLON *Bunge.*

Haloxylon recurvum *Bunge in Boiss. Fl. Or. IV. 949.*—Loc.: Chakul, 11 miles WSW of Panjgur, about 2,900 ft. (no. M 27B); Guambuk, about 50 miles SE of Panjgur, 2,700 ft. (no. M27).—Uses: Good sheep-grazing.

Vern. Name: Gwantih (Bal.).

Haloxylon salicornicum *Bunge in Boiss Fl. Or. IV. 949.*—Loc.: Nag (W. Kolwa), about 83 miles E. by N. of Turbat, about 2,300 ft. (no. M71A); 5 miles N. of Mand, about 1,000 ft. (no. M71); Bhani, 131 miles SSW of Kalat, 4,000 ft. (no. 164A); Hazarganj, 27° 28′ N, 66° 12′ E, about 3,600 ft. (no. 329); near Kanoji, 47 miles N. of Las Bela, about 3,700 ft. (no. 164B); Chhuttok, 90 miles S. of Kalat, about 4,550 ft. (no. 164).—Fl. and fr. in Sept. and Oct. 1917.

Vern. Name: Trat Bal. Br. and Serawan Br.) Laragh (Bal.), Larch (Br.), Lana (Jhalarwan Br.).

Haloxylon articulatum *Bunge in Mem Sav. Etr. Petersb. VII (1851) 468.*—Loc.: NE of Hoshap, about 60 miles ENE of Turbat, 2,000 ft. (no. M33).

Vern. Name: Landen (Bal.).

Haloxylon Griffithii *Boiss Fl. Or. IV, 950.*—Loc.: Kalat, 7,000 ft. (no. 94); Sitani (no. 118); Pishuk, 27° 32′ N, 66° 18′ E, about 5,300 ft. (no. M340); Bennchah, 21 miles N. of Surab (Jhalarwan), about 6,200 ft. (no. M34B); Surab 28° 29′ N, 66° 16′ E., about 5,700 ft. (no. M34A).—Fl. and fr. in July 1918, Aug. 1920).

Vern. Name: Bundi (Bal. and Br.)

Salsola *L.*

Salsola Kali *L. L. Sp. Pl. 222.*—Loc.: Sitani (Gidar), 59 miles S. of Kalat 5,300 ft. (no. 116); near Manguli, 197 miles SSW of Kalat, about 2,450 ft. (no. 241); Surab, 28° 29′ N, 66° 16′ E., about 5,700 ft. (no. M366B); Wad 27° 20′ N, 66° 20′ N, 66 20 E, about 4,000 ft. (no. 116B),—Fr. in June 1918, Oct. 1917.

Vern. Name: Jaghun, Soreh, Kalbahi (Br.), Kalbahi (Jharwan Br.), Jaghun (Sarwani Br.).

Salsola foetida *Del. Fl. Aegoypt. 57.*—Loc.: 4 Zarjuh (Gidar, Jhalarwan) 28° 11′ N, 66° 2′ E, about 5,200 ft. (no. M357); Shirezapatk, 27° 46′ N, 65° 37′ E, about 4,200 ft. (no. M32D); Chakul, about 11 miles WSW. of Panjgur, about 2,900 ft. (no. M32A); Sor (Kilkaur) 74 miles S. of Panjgur, about 2,300 ft. (no. M216); Rekchah, 11 miles E. of Chamba (Kolwa), about 1,800 ft. (no. M37B).—Fl. in March and April 1918.—Fr. in April 1918.

Vern. Name: Kahsakuni, Hasha (Br.), Hanshag (Bal.), Sorag, Sorago (Bal. and B.).

Girgensohnia *Bunge.*

Girgensohnia oppositifolia *Fenzl*, in Ledeb. Fl. Ross. III, 835.—Loc.: Kalat (no. M394A).

Vern. Name: Askkay.

Anabasis *L.*

Anabasis annua *Bunge Anab. Rev. 46.*—Loc.: Gwambuk, about 60 miles SE of Panjgur, about 2,700 ft. (no. M27C).—Fr. in April 1918.

Vern. Name: Gwamich (Bal).

Polygonaceae.

CALLIGONUM *L.*

Calligonum crinitum *Boiss. Diagn. ser. 2, IV, 77.*—Loc.: Dokop, 10½ miles E. of Mand, about 650 ft. (no. M60A); Tump, 46 miles W of Turbat, about 600 ft. (no. M60); Garmkan, 1 mile NE of Panjgur about 3,125 ft. (no. M60A).—Fl. & Fr. in March 1918.

Vern. Name: Pogh (Bal. and Br.).

PTEROPRYUM *Jaub & Spach.*

Pteropyrum Oliveri *Jaub & Spach III. Pl. Orient. II, 9, t. 108.*—Loc.: Tump, about 48 miles W. of Turbat about 600 ft. (no. M7); Rodkan (W. Kolwa) about 85 miles E. of Turbat, about 1,800 ft. (no. M34B); Bennchah, about 21 miles N. of Surab (Jhalarwan), about 6,200 ft. (no. E7B); Chhuttok, about 90 miles S. of Kalat, about 4,550 ft. (no. 160); Sor (Kilkaur), about 74 miles S. of Panjgur, about 2,300 ft. (no. M7A); Korak (Pelar), 180 miles SW of Kalat, 1,900 ft. (no. 160A).—Fl, in April 1918, July 1918, Aug. and Sept. 1917. Fr. in April 1918. Sept. 1917.

Vern. Name: Karawan Kush (Br. and Bal.), Mazhong, Mazhonk, Mazag (Bal.).

POLYGONUM *L.*

Polygonum polycnemoides *Jaub & Spach, III. Pl. Orient. II, 30, t. 120.*—Khudabadan, ¼ mile N. of Panjgur, about 3,100 ft. (no. M169A); Panjgur about 3,100 ft. (no. M169). Fl. in March 1918. Uses: Eaten with milk by poor people. (Hotson).

Vern. Name: Sirenchk (Bal. and Br., Hararish (Bal.).

Polygonum plebejum *Br. Prodr. 420.*—Loc.: Mohthai Kand, about 22 miles SW. of Panjgur, about 2,800 ft. (no. M131, M131A); Harbud about 55 miles E of Panjgur, about 3,700 ft. (no M169C).—Fl. and fr. in March and April 1918.

Vern. Name: Meshirhe, Hararish, Haranres (Bal.), Sirenchk, Sironch (Br.).

Polygonum persicaria *L. Sp Pl. 361.*—Loc.: Quetta.

Polygonum barbatum *L. Sp. Pl. 362.*—Loc.: Zidi, 15 miles ESE of Khozdar, about 3,600 ft. (no. 356).—Fl. in Sept. 1917.

Vern. Name: Kaba (Br.).

Polygonum aviculare *L. Sp. Pl. 362.*—Loc.: Sprin in Harboi, 19 miles ESE of Kalat, 8,800 ft. (no. 79).—Fl. and fr. in Aug. 1917.

RUMEX *L.*

Rumex vesicarius *L. Sp. Pl. 336.* Loc.: Ispikan, 16 miles NE of Mand, about 1,050 (no. M81); Kulbar Valley, some 25 miles ENE of Mand, about 1,300 ft. (no. M105).—Fl. in March 1918.

Vern. Name: Trushpanko (Bal.).

Rumex dentatus *L. Mant.* II. 226.—Loc.: Nag, (W. Kolwa), about 83 miles E by N of Turbat, about 2.300 ft. (no. M243) Khudabadan, ¼ mile N. of Panjgur (no. M196).—Fl. and fr. in March and April 1918.

Thymelaeaceae.

Daphne *L.*

Daphne oleoides *Schreb Ic. desc Pl. Decad I*, 13 *t. 7.*—Loc.: Kalgali Kaur (no. M349B); Gidar Dhor, about 85 miles S. of Kalat, about 4,700 ft. (no. 159); Wahir, 25 miles S. by W. of Khuzdar, about 4,200 ft. (no. 47D); Harboi, 18 miles ESE of Kalat, 9,000 ft. (no. 47B); under Harboi, 16 miles ESE of Kalat, 8,400 ft. (no. 47); Chhuttok, 90 miles S. of Kalat, about 4,550 ft. (no. 167). Fl. in June 1918, Aug. and Sept. 1917.—Fr. in Sept. 1917.

Uses: Poisonous to camels, horses and men. They say that when a camel eats it, his limbs become weak, he falls to the ground and rolls in pain, with profuse flowing from the mouth, nose and eyes. Although poisonous to other animals, it is (like oleander) eaten by goats without harm. The leaves are crushed and mixed with ata and oil to make a poultice for boils, etc. (Hotson).

Vern. Name: Pipal, Kirkotonk (Br.). Zaitun.

Elaeagnaceae.

Elaeagnus *L.*

Elaeagnus hortensis *M. Bieb. Fl. Taur. Cauc. II, 112.*—Loc.: Shahdadzai, 78 miles S. of Kalat, 5,000 ft. (no. 149).

Vern. Name: Sinjad (Br. etc.).

Euphorbiaceae.*

Euphorbia *L.*

Euphorbia granulata *Forsk Fl. Aeg. Arab. 94.*—Loc.: Ispikan, 16 miles NE of Mand, about 1,050 ft. (no. M74); Awaran (Kolwa), 26° 24′ N, 65° 12′ E, about 1,750 ft. (no. M74b).—Fr. in March 1918.

Vern. Name: Meshir (Bal. and Br.).

Euphorbia ? neriifolia *L. Sp. Pl. (1753) 451.*—Specimen scrappy.-Loc.: Hills S. of Chamba (Kolwa), about 26° 9′ N, 64° 42′ E, about 1,800-2,300 ft. (no. M249).—Fl. and fr. in April 1918.

Vern. Name: Dedar (Bal. and Br.).

Euphorbia helioscopia *L. Sp. Pl. 459.*—Loc.: Panjgur, about 3,100 ft. (nos. M143, M22B). Fl. and fr. in March 1918.

Vern. Name: Zahrichk—Gurbagund (Bal.).

Euphorbia turcomanica *Boiss. Cent. Euph. 13.*—Loc.: Shahdadzai, 72 miles S. of Kalat, 5,100 ft. (no. 139).—Fr. in Aug. 1917.

Uses: Is boiled and used as a medicine for gripes. (Hotson).

Vern. Name: Meshir (Br.).

* We have to thank Mr. P. M. Debbarman of the Sibpur Botanic Gardens for kindly naming the Euphorbiacae.

Euphorbia densa *Schrenk. in Bull. Phys. Math. Acad. Petersb. III (1845) 308.*—Loc. : Kalat, about 6,350 ft. no. M314C) ; perhaps also a specimen from Harboi, 18 miles ESE of Kalat, 9,000 ft. (no. 41).—Fr. in July 1918.

Vern. Name : Lappar (Br.).

Euphorbia sanguinea *Hochst and Steud. ex Boiss in DC Prodr. XV, II, 35.*—Loc.: Kochau, 122 miles SSW of Kalat, 4,150 ft. (no. 139A).—Fl. in Aug. 1917.

Uses : When used for medicinal purposes it is prepared like " bhang ". (Hotson).

Vern. Name : Meshir (Br.).

Euphorbia caeladenia *Boiss. Diagn., ser. II, IV, 81.*—Loc.: Wahir, 25 miles SW. of Khozdar, about 4,200 ft. (no. 101A).—Fr. in Oct. 1917.

Vern. Name : Lappar, Palhibahi (Br.).

Euphorbia striatella *Boiss in DC. Proder. XV, II, 152.*—Loc. : N. side of Kalgali Pass (Jhalarwan), about 28° 9′ N, 65° 56′ E, about 5,300 ft. (M 314A) ; Mazhmonk Valley, 11 miles E. of Kalat, 7,600 ft. (no. 83.).—Fl. in Aug. 1917, Fr. in June 1918.

Vern. Name : Palhidahi (Br., Karkikah (Kherani).

Euphorbia near cornuta *Pers. Syn. II, 17*—Loc.: Harbud, about 55 miles E. of Panjgur, about 3,700 ft. (no. M 114) : Mohthai Kand, about 22 miles SW. of Panjgur, about 2,800 ft. (M 22A).—Fl. and fr. in March and April 1918

Vern. Name : Koro (Bal.), Pati Bahi (B.), Zahrithk (Ketchi Bal.), Koro (Hill Bal.), Gurdagund (Panjguri Bal).

PHYLLANTHUS *L.*

Phyllanthus sp.—Specimen scrappy.—Loc. : Manguli (Jhalarwan 26° 45′ N 65° 23′ E, about 2,600 ft. (no. M 294).—Fl. in April 1918.

CHROZOPHORA *Neck.*

Chrozophora verbascifolia *A. Fuss. Tent. Euph. 28.*—Loc. : Sitani (Sidar Jhalarwan), 28° 9′ N, 66° 5′ E, 5,300 ft. (no. M 368.) ; near Padigazu, 40 miles SSW ; of Panjgur, about 3,000 ft. (no. M 21) ; Teghap, 107 miles S. of Kalat, 4,150 ft. (no. 182A)—Fl. and fr. in June 1918, Aug. 1917.

Uses : The leaves are crushed and soaked. The liquid gives a green (? blue, dye. (Hotson).

Vern. Name : Popatbahi, Kangerish (Br.). Nilb (Bal).

Chrozophora tinctoria *A. Juss. Tent. Euphorb. 23, t. 7, f. 25.*—Loc. : Hills S. of Chamba (Kolwa), 26° 9′ N, 64° 42′ E, about 1,800-2,200 ft. (no. M 21B)—Fl. and fr. in April 1918.

Uses : A blue dye is made from the fruit. (Hotson).

Vern. Name : Nilo (Bal.).

(To be continued).

REVIEW

LIFE OF SIR JOSEPH DALTON HOOKER, O.M., G.C.S.I.*

Joseph Dalton Hooker, who was born in 1817, and died in 1911, was almost the last survivor of the great group, Darwin, Wallace, Lyell, Huxley, and he played an important part in the revolution of thought which they brought about in the nineteenth century. His unique knowledge of plants and their distribution contributed to the evidences for evolution, and he was Darwin's confident, his keen but friendly critic, and his ardent champion. One of his gifts to posterity was this contribution to the new movement; another was the gradual transformation of Kew from little more than a park to a national institution of world-wide importance, which work was begun by his father and completed by himself in spite of official indifference and even opposition. His third great gift is the written works he has left, especially the Genera Plantarum (in which Bentham collaborated), the Index Kewensis, which was financed by Darwin as a gift to the nation, and his various floras with their instructive introductory essays.

Hooker's opportunities of studying plants were unrivalled, owing to his Botanical expeditions in different parts of the world, and the collections in his charge at Kew; but they were opportunities often hardly won and beset with difficulties, and his tireless industry never brought him enough of this world's goods to make his work easy.

His first journey in 1839, when only twenty-two years old but already with a reputation as a botanist, was with Ross to the Antarctic; and as the objects of the expedition were to establish magnetic observatories at St. Helena, the Cape and Van Dieman's Land, to make observations at various oceanic islands, and then to determine, if possible the position of the South Magnetic Pole and generally to explore the Antarctic regions, Hooker had opportunities for collecting plants from many localities. His equipment was of the scantiest, Government supplying him with nothing but drying-paper and some collecting-cases; the only glass bottles available were empty pickle bottles, and the only preservative rum from the ship's stores. Fortunately his father had given him microscopes and books, and though at first he had to wait to arrange his collections after an expedition ashore until his messmates were in bed, Capt. Ross soon provided space and a cabinet in his own cabin, where however damp and cockroaches had to be contended with, and in rough seas the microscope had to be lashed to the table. In spite of all difficulties, young Hooker collected assiduously, and scarcely needed his father's letters urging him to stick to his work and avoid unnecessary entertainments; this stern parent thought it a frivolous amusement to join a riding excursion in Madeira to see an ancient crater in the heart of the mountainous island.

* Life and Letters of SIR JOSEPH DALTON HOOKER, O.M., G.C.S.I. Based on materials collected and arranged by Lady Hooker. By Leonard Huxley. 2 *Vols. VII and 546, and VIII to 569 pp. London, John Murray, 1918.*

The luxuriant plant life in Madeira was a great joy to him; yet he was no less happy in desolate Kerguelen's Land. As a small child he used to look at a picture of this place, when sitting on his grandfather's knee and turning over the beloved pages of Cook's Voyages. The picture showed a strange arched rock, and the sailors killing penguins; and he thought he would be the happiest boy alive if ever he could see that wonderful rock and knock penguins on the head. The island is storm-swept, and the hill-tops were always covered with ice and snow, the vegetation is scanty, consisting largely of cryptogams, but Hooker collected every day of the two months' stay, and exclaims in a letter home: "You cannot conceive the delight which the new discoveries afforded as they slowly revealed themselves, though in many cases it was all I could do to collect from the frozen ground as much as would serve to identify a species Many of my best little Lichens were gathered by hammering out the tufts or sitting on them till they thawed." Lichens painted the rocks from the water's edge to the summit of the hills. And there they appeared like a miniature forest growing on the flat rocks: one was of a delicate lilac colour, another bright yellow, and another tinged whole caves near the sea with a light red. Much interest was taken in the so-called Kerguelen Cabbage (*Pringle's anti-scorbutica*) discovered by Cook and eaten to prevent scurvy: Hooker grew it from seed and planted it on the Falkland Islands elsewhere.

At St. Helena he was greatly interested in what was afterwards called "the struggle for existence" between the native and imported plants and animals.

Arriving at Cape Horn just as winter ended, he thought the climate had been much abused, for spring came with a rush in ten days: "the Berberry flowered with bright golden blossoms, the tufts of Misodendrons on the beeches grew quite brilliant, and the crumply-leaved beech burst at every twig, emitting a delicious resinous smell." But in a few days snow came down, and thence forward clouds and fogs, rain and snow, justified all Darwin's descriptions (in the Voyage of the Beagle) of the dreary Fuegian summer.

Within the Arctic Circle, Hooker dredged for sea-animals and made drawings and studies of them, as there was no work for a botanist. Even a seaweed was only found here once, and at Cockburn Island one sole lichen was found, painting the rocks with red and orange,—a lichen which is abundant also in the Arctic regions. Hooker was destined to find it again, to his surprise, at 19,000 ft. in the Himalayas, where "my most Antarctic plant, *Lecanora miniata*" forms once more the only vegetation at an extreme limit of vegetable life, and stains the rocks so as to show them orange-red at a distance of five miles, exactly as on Cockburn Island.

Although unable to reach the position of the South Magnetic pole, Capt. Ross discovered the great Barrier and the sea which bears his name, and the members of his expedition were the first to see the wonderful volcano named after his ship Erebus.

Hooker's letters on this expedition show how much more he was than a collector and systematist, for he was constantly considering the significance of the facts he noted, especially the distribution of the species; and his *Flora Antarctica* and the separate floras of New Zealand, Tasmania, and Australia, etc., which he afterwards published suggest far-reaching problems. He was impressed with the idea that there must have been an ancient southern continent from which forms had spread to places now so disconnected as New Zealand and Chili, where

the same genera and even species are found. Another outstanding fact, for which he was not prepared, was the way in which his species from different regions run into one another, for he naturally at this time accepted the belief of his day that they were all fixed and distinct. His work therefore prepared him to accept Darwin's view when known, yet his native caution and critical spirit made him slow to adopt it, and at first he merely accepted it as a working hypothesis, giving scope for reason and reflection, and hopes of a rational explanation of the origin and dispersal of species, whereas "the old stick-in-the-mud doctrines of absolute creations, multiple creations, and dispersion by actual causes under existing circumstances are all used up, they are so many stops to further inquiry: if they are admitted as truths, why there is an end of the whole matter." The *Flora of New Zeland* was based on the old principle, but when the Tasmanian Flora was published he had wholeheartedly adopted the new.

Hooker's second and most important botanical journey, after the Antarctic expedition, was to the Himalayas. On his way out to India, when stopping at Cairo, he made a trip into the desert, that he might make some observations on its temperature and dryness, in order to see how near the starving and burning point vegetation would exist, in comparison with his many observations in the Antarctic of how much cold they would bear.

The story of his experiences in India has been told in his Himalayan Journals, his delight in the wealth of beautiful plants in the mountain jungles, his difficulties in collecting and preserving in monsoon weather, his native collectors and the elephant that gathered inaccessible plants for him, his imprisonment and ill-treatment by a hostile Dewan. Many of his specimens were lost or spoiled, but hundreds of cases reached safety. The rhododendrons required a book for themselves which was finely illustrated and edited by his father. At 18,000 ft., where no other known shrub grows, he discovered the little *Rhododendron nivale* with matted branches straggling on the ground, small scented leaves and purple flowers, struggling successfully against the rigours of the climate —scorching sun followed by keen frost at night, utter drought followed by extreme moisture, short time for blooming and few insects to help in fertilisation. His vivid description makes one regret more keenly than ever that one who could write thus sympathetically of plants should have been obliged to cut down the *Flora of British India* to so bare a description of each species. The volume brought out with the co-operation of his friend and companion Thomson, had an Introduction of 280 pages, and an equal amount of description, extending only from Ranunculaceae to Fumariaceae; but the East India Company refused any assistance, and the authors were so much out of pocket by their venture that it was impossible to continue the work on the same scale. Fifteen years after, in 1870, the India Council was moved to take an interest in the matter, and for twenty-seven years Hooker worked at the *Flora*, with help of various collaborators, and utilizing the collections of Wight, Falconer, Griffith, Wallich and others for all the districts of India not visited by himself. The last three volumes of the seven were brought out after his retirement from Kew, and to the end of his long life he continued to work at Indian botany, which he loved, revising the Indian balsams, and comparing them with African and Chinese balsams, delighted to find when over 90 years of age that "eyes and fingers are good as ever".

The F. B. I., he calls a pioneer work merely, and often expressed a great wish to see India properly botanized. The specimens from which he

worked were often badly preserved, badly mounted, and without notes, even of the colour of the flowers. He insisted much upon the necessity for observation in the field. Comparing the Indian with the Australian flora, he remarked that many typical forms from the Indian tropics exist in Australia, but no Australian plants seem to have found their way to India, although the eucalyptus flourishes when planted on Indian soil.

After his return from India, Joseph Hooker became his father's assistant at Kew, and it was not until 1860 that he undertook another botanical expedition. This was to Palestine and the results of his travels there were afterwards condensed into a masterly sketch of the Botany of Syria and Palestine for Smith's Bible Dictionary. His chief ambition was to ascend Mount Lebanon and examine the Cedars, comparing them with the Indian deodars. He found them decadent, no seedling being apparently able to survive the present dry climate, so that all the existing trees were from 50 to 500 years old. At 3,000 to 4,000 feet, he found the Lebanon scenery "Tibetan and wretched", and above 8,000 feet, the vegetation was extremely scanty. There was but one alpine or arctic plant, *Oxyria reniformis*, and that grew only at the summit and was very rare: he concluded that this indicates the same change of climate as is shown by the cedars, and that other arctics which probably existed there in earlier times when the climate was more moist have been expelled by the increasing drought. Their absence is characteristic of the mountains of Asia Minor also and of Morocco as Hooker himself found later. The Cedars of Lebanon he strongly held to be of the same species as the Indian Deodars, these being two extreme forms of one extinct type and their difference of habit due to the contrasted climates of dry Lebanon and humid Himalaya, especially as he had seen the two forms growing side by side at Dropmore and looking quite alike. His paper on the whole genus includes observations on the Cedars of Algeria, Lebanon, the Taurus, and India.

Eleven years later, in 1871, Hooker went to botanize in Morocco, looking forward to "tasting the delights of savagery again", and fufilling another childish ambition, inspired by Mungo Park's Travels, of ascending the Great Atlas. He found it politic to pose as the *hakim* and gardener of the Great Sultana Victoria, and the people believed he was searching for a herb which would enable her to live for ever! Here the labour of collecting and of drying in the moist atmosphere, would have been "almost intolerable. but for the compensating pleasures". Often his collaborator Ball would work by their one candle till about 2 a.m., and then Hooker would take up the task until morning. He decided that the flora of the Atlas was the dying out of the European flora, and the difference on either side of the Straits of Gibraltar emphasised the antiquity of the severance.

Hooker's last botanical expedition, undertaken at the age of sixty, was made in company with Asa Gray, who was five or six years older, but the two elderly botanists were indefatigable in their survey of the North American flora, although their journey from East to West included an ascent of a peak 14,500 feet high in the Rockies, where for five hours they had to force their way through thick forest, and a ten days' wagon journey across the Sierra Nevada to the Yosemite Valley. The two problems which they were most anxious to solve were Gray's of the connection between the plants of the Eastern States with those of East Asia and Japan, and Hooker's of the hard line of division between the Arctic flora of America and Greenland. They agreed that both might have resulted from a glacial period and a former connection with an Arctic continent. The warm-climate types of plants now found in North Polar regions as fossils had

been pushed south by the advancing ice into America as well as Asia, and had found congenial sites in the forest area of the east coast of America, but the ice-cap remaining long on the Rockies, had prevented these plants from settling there except in some favoured localities, while the desert region which developed in the middle of the continent prevented the eastern plants from re-invading the Rockies, which were eventually peopled largely from Mexico. With regard to Greenland, Hooker believed that the advance of the ice-cap there had pushed the plants into the sea, so that there could be no return for them, and nore-peopling from elsewhere, hence the paucity of the Greenland flora. He was inclined to accept Buffon and Saporta's view that vegetable life may have begun at one of the poles, because these would be the first regions to become cool enough to support life, and the balance of evidence seemed to him to point to the north pole, because distribution has apparently flowed in general from north to south, as already noted with regard to India and Australia. Scandinavian types are very widely distributed; and old types, such as cycads and Proteaceae have perhaps reached the southern hemisphere in quite recent geological times, while becoming almost extinct in the north.

After this journey in America, Hooker had botanized in all the continents of the world, as well as on many oceanic islands. Yet these expeditions formed the smallest part of his life-work: for the greatest part he was at Kew, where he worked up not only his own collections but those of others. He published a Flora of the Cameroons, wrote on the Galapagos, plants, and on the distribution of Arctic Plants. The immense herbarium was gradually brought into order and constantly added to, the gardens were improved, and new buildings added; he was always ready to make observations and experiments for Darwin on the structure of orchids, the habits of carnivorous plants, etc., and he took a great interest in the economic botany of the Empire. In the 70's there was a great demand for eucalyptus trees to combat malaria, and many were supplied from Kew: to Hooker was due the importation of rubber, of which he foresaw the importance, into Ceylon, Fiji, Australia, Java, and Zanzibar; Liberian coffee first grown at Kew became a flourishing crop in the East and West Indies; chocolate was introduced into Ceylon, cinchona establlshed in India, and various fodder grasses were taken to new centres. The cigar industry in Jamaica was due to Hooker, and together with other crops, such as cinchona and fruits, rescued the island from bankruptcy when the sugar industry failed. Hooker's advice was that small cheap botanical gardens, for economical plants only, should be started in all our colonies.

After being Sir Willian Hooker's assistant at Kew from 1855, Sir Joseph naturally stepped into his father's place when the latter died, and was Director of Kew from 1865 to 1885. On his retirement, a private letter from Lord Iddesleigh expressed the opinion that Kew would be to Joseph Hooker what St. Paul's was to Wren. Sir Joseph sent thanks in the name of his family, so as to include his father, to whom he was always loyal by devoted, and in a letter to a friend be acknowledges that "Kew is what my father and I have made it by our sole unaided efforts." His influence on botanical science was felt in many ways, especially as he was member of many scientific and learned societies, and President of the Royal Society. He retired only to work harder than ever at his plants, freed from the administrative and offiicial duties of his position at Kew.

Although he was twice married, none of Hooker's children became botanists, but his daughter's husband, William Thistleton-Dyer, who had been his private secretary, succeeded him as Director at Kew.

The two stout volumes from which this brief account is taken, are interesting throughout, and seem to make one really acquainted with a rare and delightful personality. One realizes his passion for plants from first to last, an inheritance from both his father and his mother's father, Dawson Turner; and his development can be traced, from the reserved puritanical youth who shuns society and refrains from collecting plants on Sundays, to the genial host at Kew and the correspondent of Darwin, full of fun and broad modern views. A chapter by Prof. Bower summarizes admirably Sir Joseph Hooker's position as botanist. In two appendices are given a complete list of his writings, and the long roll of honours and appointments conferred upon him. The illustrations are all well chosen, and include six portraits of the botanist at different periods, and two pictures of his camp life, one in Sikkim, with his Lepcha collectors and Gurkha guard, and one in the Rockies with Asa Gray and other American friends. A welcome feature of the book is a brief biographical notice in a footnote of each notable person mentioned in the text, and there is a good index.

M. A. EVERSHED.

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During my absence from India on furlough the editing of this journal will be in the hands of the

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THE PHYSIOLOGICAL ANATOMY OF THE PLANTS OF THE INDIAN DESERT

BY

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(*Continued from p. 247.*)

LYTHRACEAE—(*Contd.*)

The mesophyll is composed of palisade tissue on the upper side and of arm-palisade tissue on the lower. Internal secretory organs are not found. Oxalate of lime occurs in the form of clustered crystals near the veins in *A. desertorum.*

The veins are embedded and are enclosed in green bundle-sheaths.

Hairy covering is found on the axis and on the upper surface of the leaf of *A. desertorum* and consists of unicellular conical hairs with verrucose walls and sometimes seated on a group of two or three epidermal cells (fig. 126). Glandular hairs are not found.

Structure of the Axis :—The epidermis is composed of tabular cells with outer walls thickened, verrucose and convexly arched outwards. The inner walls are thickened; and the lateral walls are thin and straight. The axis is ribbed at the angles. The cortex is composed of chlorenchyma extending to the ribs.

The pericycle forms a loose ring of bast fibres, those in *A. baccifera* having thin walls and large lumina. The wood is composite. The vessels are uniformly distributed in incomplete rows, vessels becoming larger towards the inner margin of the wood. The interfascicular wood prosenchyma is composed of cells with thin walls and large lumina and is more extensive in the upper half. The medullary rays are uniseriate and numerous. Wood parenchyma is abundantly developed at the inner margin of the wood cylinder.

The pith is composed of thin-walled cells and is characterised in *A. baccifera* by small groups of thick-walled cells, having the same size and shape as that of the pith cells. These cells form probably the strengthening tissue of the pith.

ONAGRACEAE

Trapa bispinosa *Roxb.*—Fig. 127. *Leaf only.*—Epidermis formed of tabular cells with outer walls very greatly thickened on the upper surface. Stomata occurring only on the upper surface. Clothing hairs in the form of uniseriate trichomes and found only on the lower surface. Mesophyll formed of palisade tissue on the adaxial side and of spongy tissue on the abaxial side. Spongy tissue characterised by large intercellular spaces. Oxalate of lime found in the form of numerous clustered crystals. Veins embedded and not provided with bundle-sheaths.

Structure of the Leaf.—The epidermal cells are tabular and thin-walled on the lower surface. The outer walls of the epidermal cells on the upper surface are very greatly thickened. The lateral walls are straight. Stomata occur in large number only on the upper surface and are surrounded by ordinary epidermal cells. Guard-cells are situated in the plane of the surrounding cells and the front cavity is on a level with the surface. Closure of the stomata seems to take place by the well developed cuticular ridges of the guard-cells (fig. 127).

Hairy covering consists of long uniseriate thin-walled trichomes occurring only on the lower surface (fig. 127). External glands are not found.

The mesophyll is composed of long-celled palisade tissue on the adaxial side and of spongy on the abaxial side which is characterised by large intercellular spaces. The system of large intercellular spaces helps the leaves to float on the surface of water.

Internal secratory organs are not found. Oxalate of lime occurs in the form of numerous clustered crystals in the spongy tissue. The cells containing clustered crystals are arranged in small groups projecting into the intercellular spaces. Larger clustered crystals are isolated and occur in the palisade tissue.

The veins are embedded and are not enclosed in bundle-sheaths.

CUCURBITACEAE

Momordica dioica *Roxb.*—Figs. 128, 129, 130. 131. Leaves membraneous. Guard-cells elevated. Mesophyll formed of short-celled palisade tissue on the upper side and of spongy tissue on the lower. Trichomes on the leaf provided with subsidiary cells not

elevated above the base of the trichomes. Cystolith-like structures not found in the basal cells of the trichomes. Branches deeply furrowed. Pericycle forming a continuous undulated ring of stone-cells. Collenchyma developed in the angles.

Cucumis Melo *L.*—Figs. 132, 133, 134. Guard-cells elevated above the epidermis. Mesophyll composed of short-celled palisade tissue on the adaxial side and of spongy tissue on the abaxial side. Trichomes on the leaves provided with subsidiary cells not raised above the base of the trichomes. Axis obtusely angular with stiff long trichomes on the ridges. Collenchyma forming a continuous undulated ring below epidermis. Cystolith-like structures in the basal cells of the trichomes on the leaf. Some of the cells of soft bast as well as some of those of the ground tissue, separating the vascular bundles, with tanniniferous contents. Pericycle forming a continuous ring of stone-cells.

Citrullus Colocynthis *Schrad.*—Figs. 135, 136. Guard-cells much elevated above the epidermis. Mesophyll formed of long-celled palisade tissue on the adaxial side and of arm-palisade tissue on the abaxial side. Trichomes on the leaf provided with subsidiary cells raised above the base of the trichomes. Cystolith-like structures found in the basal cells of the trichomes on the leaf. Groups of colourless palisade-like cells below the lower epidermis forming water-cells. A few cells of soft bast with tanniniferous contents. Axis not much angled. Pericycle formed of closely placed groups of stone-cells. Collenchyma developed in the larger angles.

Melothria maderaspatana *Cogn.*—Figs. 137, 138. Guard-cells much elevated above epidermis in the leaf; and situated on a pedestal on the axis. Mesophyll formed of long-celled palisade tissue on the adaxial side and of spongy tissue on the abaxial side. Trichomes on the leaf provided with subsidiary cells not much raised above the base of the trichomes. Cystolith-like structures found in the basal cells of the trichomes. A few cells of soft bast with tanniniferous contents. Pericycle forming a continuous undulated ring of stone-cells. Axis deeply furrowed. Collenchyma developed in the ridges.

Structure of the Leaf.—The epidermis consists of polygonal cells with outer walls a little thickened. The lateral walls are undulated. Cystolith-like structures occur in the basal epidermal cells of the trichomes on the leaf except in *Momordica dioica*. The stomata are more numerous on the lower surface and are surrounded by ordinary epidermal cells. The guard-cells are elevated. The front cavity i placed in a depression formed by the outer thickened epidermal walls in species of *Citrullus*; in species of other genera it is situated on a

level with the surface. The stomata on the axis are found at the apex of pedestals formed by epidermal cells. The pedestals are quite conspicuous in *Melothria maderaspatana* (fig. 138).

The mesophyll is composed of palisade cells, which are much shorter in *Momordica dioica* and *Cucumis Melo*, on the adaxial side and of an extensive spongy tissue on the abaxial side. The spongy tissue is replaced by arm-palisade tissue in *Citrullus Colocynthis*. There are groups of colourless palisade-like cells below the lower epidermis of *Citrullus Colocynthis*; these groups of cells may form water-cells.

The veins are embedded and are not provided with bundle-sheaths. They are vertically transcurrent.

The hairy covering consists of clothing and glandular hairs. The clothing hairs are more numerous on the lower surface and consists of simple uniseriate thin-walled trichomes seated on subsidiary cells which are raised above the base of the trichomes in *Cucumis Melo* (fig. 134) and in *Melothria maderaspatana*. The trichomes on the axis are accompanied by numerous subsidiary cells, which form a pedestal-like structure (fig. 132). The constituent cells of the trichomes are dilated at the base, thus giving them a somewhat jointed appearance.

The external glands on the leaf and axis are composed of a short uniseriate stalk usually placed in epidermal depressions and of an ovoid head divided by horizontal and vertical walls. Glandular hairs seem to be more numerous on the upper surface in *Momordica dioica*.

Structure of the Axis.— The epidermis consists of small polygonal cells with outer walls a little thickened. Axes are deeply five-grooved except in *Citrullus Colocynthis* where the ridges and the furrows are very slight.

The cortex is characterised by an assimilatory tissue formed of chlorenchyma. The collenchyma is sub-epidermal; it is developed in the angles in *Momordica dioica* and in *Melothria maderaspatana* (fig. 136); in *Cucumis Melo* it forms a continuous ring thickened in the angular portions. In *Citrullus Colocynthis* collenchyma is developed below the epidermis of the larger angles.

The pericycle forms a composite undulated ring of stone-cells except in *Citrullus Colocynthis* where it is composed of closely placed groups of stone-cells.

The vascular bundles are bicollateral and are arranged in two rings five in each ring. The bundles in the outer ring are much smaller and occur below the angles where they are conspicuous. Smaller bundles project towards the exterior and the larger towards

the interior. The bundles are connected together by broad strips of ground tissue which resemble medullary rays. Bundles in the inner ring almost meet in the centre in *Citrullus Colocynthis* and in *Melothria maderaspatana*. The vessels expecially those of the bundles of the inner ring have very wide lumina.

A few cells of soft bast on either side of the bundles hold tanniniferous contents in all members except *Momordica dioica*.

The pith is greatly reduced on account of the bundles of the inner ring projecting inwards. It consists of a few thin-walled cells.

General Review.—The epidermal cells have outer walls a little thickened. The mesophyll is bifacial. Stomata are usually elevated above the epidermis, much more so on the axis where they are usually situated at the apex of pedestals formed by the subsidiary cells. The stomata, as a rule, are more numerous on the lower surface of the leaf. The hairy covering consists of uniseriate thin-walled trichomes seated on subsidiary cells which, on the axis, are raised above the base of the trichomes in the form of a pedestal. The trichomes are somewhat jointed and more numerous on the lower surface of the leaf. Internal secretory organs are represented by a few isolated cells of soft bast with tanniniferous contents in all members except *Momordica dioica*. The glandular hairs are placed in epidermal depressions and consist of a short uniseriate stalk and of an oval head divided by horizontal and vertical walls. The pericycle forms a continuous and undulated ring of stone-cells or it is formed of closely placed groups of stone-sells. Collenchyma is developed below the epidermis of the angles. The vascular bundles are bicollateral and are situated roughly in two rings. The bundles of the outer ring are much smaller and are situated below the angles; bundles belonging to the inner ring are much larger and are placed below the furrows; smaller and larger bundles project outwards and inwards respectively. The bundles are separated from one another by broad strips of ground tissue resembling medullary rays. The vessels have wide lumina and simple perforations. The pith is greatly reduced as the bundles of the inner ring almost meet in the centre.

FICOIDEAE

Trianthema triquetra *Rottl. & Wild.*—Figs. 139, 140. Leaves fleshy. Mesophyll characterised by an extensive aqueous tissue. Stomata found only on the lower side of the leaf. Arcs of palisade cells on the lower side. Veins embedded and half enclosed with green bundle-sheaths. Clustered crystals found near the veins, in the cortex and in the pith. Some of the epidermal cells bladder-like and attenuated at the apices into hair-like structures. Axes angled. Wood

belonging to the second type. Groups of soft bast embedded in the wood cylinder. Pith formed of thin-walled cells.

Trianthema pentandra *L.*—Figs. 141, 142, 143. Some of the epidermal cells bladder-like and attenuated at their apices into hair-like structures. Mesophyll bifacial. Clustered crystals near the veins, in the cortex and pith. Veins provided with green bundle-sheaths. Branches angled and grooved. Sclerenchymatous pericycle not developed. Wood belonging to the second type. Pith formed of thick-walled cells.

Orygia decumbens *Forsk.*—Figs. 144, 145, 146, 147. Mesophyll composed of palisade tissue on the adaxial side and of arm-palisade tissue on the abaxial side. Veins not provided with bundle-sheaths. Clustered crystals found near the veins, in cortex and in pith. Axes obscurely angled. Assimilatory tissue in the axis formed of chlorenchyma. Collenchyma developed in the angles. Pericycle forming a composite ring of stone-cells. Wood belonging to the third type. Pith formed of thin-walled cells.

Mollugo hirta *Thunb.*—Figs. 148, 149, 150. Clothing hairs forming a dense covering of stellate hairs. Mesophyll isobilateral. Star-like bundles of acicular crystals in the mesophyll. Veins embedded and without bundle-sheaths. Assimilatory tissue formed of chlorenchyma. Clustered crystals found in the cortex and in the pith. Pericycle formed of a composite ring of stone-cells. Pith composed of thin-walled cells.

Mullugo nudicaulis *Lam.*—Figs. 151, 152, 153. Mesophyll bifacial. Styloids found in the spongy tissue. Veins embedded and without sheaths. Clustered crystals in the neighbourhood of the veins. Assimilatory tissue in the axis formed of chlorenchyma. Structure of wood belonging to the first type. Pith formed of thin-walled cells.

Mullugo Cerviana *Ser.*—Figs. 154, 155. Some of the epidermal cells larger and with water-storing function. Mesophyll isobilateral. Veins embedded and provided with green bundle-sheaths. Assimilatory tissue in the axis in the form of chlorenchyma. Sclerenchymatous pericycle forming a composite ring. Structure of wood belonging to the first type. Pith formed of thin-walled cells.

Gisekia pharnaceoides *L.*—Fig. 156. Leaves sub-fleshy. Mesophyll bifacial. Veins embedded and without bundle-sheaths. Bundles of acicular crystals found near the veins, in the cortex and in the pith. Axes angled. Sclerenchymatous pericycle forming a composite ring. Structure of wood belonging to the third type. Pith formed of thin-walled cells.

Limeum indicum *Stocks.*—Figs. 157, 158, 159. Some of

the epidermal cells large and having water-storing function. Mesophyll isobilateral. Clustered crystals found near the veins and in cortex. Hair-like structures, with walls thickened and superficially rugose, found on the leaf. Pericycle formed of rhomboidal groups of stone-cells, Pith formed of thick-walled cells.

Structure of the Leaf.—The epidermis consists of polygonal cells with outer walls thickened, papillose and superficially granulated, except in species of *Mollugo* in which the cells are very thin-walled. The thickening of the outer walls is considerable in *L. indicum* (fig. 157). Some of the epidermal cells in *T. pentandra* (fig. 114) are bladder-like and are attenuated at their apices into hair-like structures ; they are numerous on the lower side of the mid-rib. There are also, in *M. Cerviana* and *L. indicum*, large cells intercalated amongst the epidermal cells of ordinary dimensions. All these specialised cells seem to have the function of absorbing and storing water. The lateral walls are thin and undulated.

The thinness of the outer walls, specially in *M. hirta* and *M Cerviana*, can be accounted for by the presence of a protective covering of dense stellate hairs and by the occurrence of large water-storing epidermal cells.

The stomata are usually numerous on both the surfaces of the leaf and are surrounded by ordinary epidermal cells. The front cavity is placed in a depression formed by outer thickened and papillose epidermal walls (figs. 145, 158). The stomata in *T. triquetra* (fig. 139) are elevated and occur only on the lower surface, owing to the occurrence of an extensive aqueous tissue on the upper surface. The guard-cells are usually elevated, though in *T. triquetra*, *T. pentandra* and in *M. Cerviana* elevated guard-cells occur side by side with guard-cells situated in the plane of the surrounding cells. The stomata are, as a rule, numerous and can be accounted for by the fleshy character of the leaf.

The mesophyll is isobilateral in *M. hirta* (fig. 150) and *M. Cerviana* (fig. 154), in other members it is bifacial. The mesophyll, in *T. Pentandra* (fig. 141), *M. nudicaulis* (fig. 151) and *G. pharnaceoides*, consists of palisade tissue on the upper side and of spongy tissue on the lower. The structure of the mesophyll in *T. triquetra* is characteristic ; it consists on the abaxial side of a subepidermal aqueous layer and of arcs of palisade cells on the lower side of the veins and on the adaxial side of an extensive aqueous tissue of large polygonal cells. In *O. decumbens* and *L. indicum* (fig. 157) there is palisade tissue on the upper side and arm-palisade tissue on the lower.

Internal secretory organs are not found in the leaf and axis. Oxalate of lime occurs in the form of numerous large clustered cry-

stals in the neighbourhood of the veins in *T. triquetra*, *T. pentandra*, *O. decumbens*, *M. nudicaulis* and *L. indicum*. Besides clustered crystals near the veins, there are solitary ones in the spongy cells of *M. nudicaulis* (fig. 151). Palisade cells on both sides, in *M. hirta* (fig. 150) and *M. Cerviana* (fig. 154), contain small bundles of needle-like crystals and solitary crystals respectively. Oxalate of lime is found in the form of bundles of acicular raphides in *G. pharnaceoides*.

The veins are embedded in all members; they are provided with bundle-sheaths of green, thin-walled cells in *T. pentandra* and *M. Cerviana*. Sheath-cells are colourless in *L. indicum*. Veins in *T. triquetra*, are provided only on the lower side with arcs of green bundle-sheath cells, owing to the occurrence of the assimilatory tissue on the sides of the veins.

Hairy covering on the leaf and axis is found only in *M. hirta* and consists of stellate hairs with an uniseriate stalk and a star-shaped terminal cell (figs. 148, 149, 150). In *L. indicum* (fig. 157), there are papillae-like unicellular structures with walls thickened and superficially rugose. They may have been developed from epidermal outgrowths which were afterwards separated by transverse walls; they may have a water-storing function. External glands are found only in *L. indicum* in the form of capitate glandular hairs (figs. 157, 159).

Structure of the Axis.—The epidermis consists of polygonal cells with outer walls thickened. Lateral walls are thin and undulated Inner walls are also thickened in *T. triquetra*, *T. pentandra*, *O. decumbens*, *M. hirta* and *G. pharnaceoide*. There are large bladder-like cells, attenuated at their apices into hair-like structures, intercalated amongst epidermal cells of ordinary dimensions in *T. triquetra* (fig. 140) and in *T. pentandra* (fig. 143). These cells may have a water-storing function. The stomata are like those on the leaf.

The primary cortex is represented by a thin-walled parenchymatous assimilatory tissue in *O. decumbens* and in species of *Mollugo*. Collenchyma is developed in the angular portions of *O. decumbens*. The primary cortex, in other members, is formed of colourless cortical parenchyma.

The pericycle is formed of a more or less composite ring of stone-cells in *O. decumbens* (fig. 146), species of *Mollugo* (figs. 149, 153, 155) and *G. pharnaccoides*. In species of *Mollugo* the ring of stone tissue is very thick. The pericycle in *L. indicum*, consists of rhomboidal groups of stone-cells; in other members it is not sclerenchymatous, which is compensated for perhaps by extensive interfascicular wood prosenchyma which is very little developed in species of *Mollugo*. It seems, therefore, that the development of sclerenchymatous pericycle is inversely proportional to that of interfascicular wood prosenchyma.

The wood is composite in all members. In species of *Trianthema* it is composed of numerous xylem bundles which are embedded in interfascicular wood prosenchyma in more or less distinct concentric rings (figs. 140, 143). In species of *Mollugo* it is composed of large xylem bundles with vessels large and numerous and with little interfascicular wood prosenchyma (figs. 149, 153, 155). Vessels, in *O. decumbens*, *G. pharnaceoides* and *L. indicum*, are large and numerous and are uniformly distributed in the interfascicular wood prosenchyma. Thus the structure of the wood can be classified into three types—*M. nudicaulis* and *M. Cerviana* representing one type species of *Trianthema* another and *O. decumbens*, *M. hirta*, *G. pharnaceoides* and *L. indicum* the third type.

The structure of the wood has undergone modifications

(1) either due to the decumbent habit as in *O. decumbens* in which the wood cylinder is very much narrowed and the vessels are few and small on the lower side of the axis.

(2) or to the direction of the prevailing wind as in *T. triquetra*, *G. pharnaceoides* and *L. indicum*, in which larger xylem bundles with vessels larger and more numerous occur on two opposite sides of the axis which represent the plane of the direction of the prevailing wind, while in a plane at right angles to this occur much smaller xylem bundle with vessels much smaller and less numerous.

These modifications are the result of greater functional activity on those sides which are more affected by wind in the case of erect axes, or by the sun and wind together in case of prostrate axes.

The pith consists of thick-walled calls in *T. pentandra*, *M. hirta* and *L. indicum;* in other members it is formed of thin-walled cells.

Oxalate of lime is found in the form of clustered crystals in the cortex and pith of *T. triquetra*, *T. pentandra*, *O. decumbens* and *M. hirta*; in *L. indicum* clustered crystals occur only in the cortex. Acicular crystals are found in the cortex and pith of *G. pharnaceoides*.

Anomolous structures are represented by groups of soft bast embedded in the wood cylinder in *T. triquetra*.

General Review.—Epidermis consists of polygonal cells with outer walls usually thickened. Large bladder-like cells with water-storing function are intercalated amongst epidermal cells (figs. 141, 143). Stomata are depressed and are accompanied by ordinary epidermal cells. The mesophyll in *T. triquetra* (fig. 139) is characterised by an extensive aqueous tissue. Oxalate of lime is found in the form of clustered crystals in the leaf and axis of most of the members. Styloids occur in *M. nudicaulis* and *M. Cerviana;* acicular crystals are present in *G. pharnaceoides*. Hairy covering is present only an *M. hirta*

and consists of stellate hairs. There are unicellular papillae-like— structures in *L. indicum*, (fig. 157), with walls superficially rugose and perhaps with a water-storing function.

The pericycle is composed of stone-cells, except in species of *Trianthema*. Wood is composite and can be classified into three types as described already. The structure of the wood undergoes modifications either due to the prostrate habit of the axis or to the action of wind in case of erect axes. The perforations of the vessels are simple. The pith consists of thin-walled or thick-walled cells.

RUBIACEAE

Oldenlandia aspera *DC.*—Fig. 162. Epidermal cells with outer walls convexly arched outwards. Mesophyll formed of short-celled palisade tissue. Unicellular dome-like structures with thickened and muriculate walls found on the axis. Epidermal cells of the axis with both outer and inner walls thickened. Internal secretory organs and oxalate of lime not found. Sclerenchymatous pericycle absent. Soft bast of thick walled-cells. T. S. of the axis circular.

Spermacoce hispida *L.*—Figs. 160, 161. Upper epidermal cells larger and with outer walls usually toothed in the middle. Mesophyll composed of palisade tissue on the upper side and of spongy tissue on the lower. Internal secretory cells with tanniniferous contents numerons in the mesophyll. Secretory cavities found in the mesophyll and cortex. Acicular crystals found in the cortex. Clothing hairs in the form of articulated uniseriate trichomes. Epidermal cells of the axis with outer walls thickened. Axes quadrangular. Angles bearing wing-like ribs. Pericycle forming a loose ring of bast fibres.

Structure of the Leaf.—The epidermal cells are polygonal with the outer walls greatly thickened and convexly arched outwards. The outer walls of the upper epidermal cells of *S. hispida* are toothed in the middle, while those of the epidermal cells on both the surfaces in *O. aspera* are sometimes papillose. Lateral walls are thin and undulated; inner walls are thin.

The stomata are accompanied by subsidiary cells and are more numerous on the lower surface. The guard-cells are situated in the plane of the subsidiary cells which are elevated above the surrounding cells. The front cavity is placed in depressions formed by the outer thickened walls of the surrounding cells. The stomata on the axis have the same characters as of those on the leaf (fig. 162).

The mesophyll in *O. aspera* is composed wholly of short palisade cells; it is bifacial in *S. hispida*. Internal glands occur only in *S. hispida*, and are represented by mucilaginous secretory cavities

with acicular raphides (fig. 160) in the assimilatory tissue in the leaf and axis. Besides these, there are assimilatory cells in the mesophyll with tanniniferous contents (fig. 160 *G.*).

Oxalate of lime occurs only in *S. hispida* either in the form of acicular raphides in the mesophyll and pith (fig. 161 A. R.), or in the form of crystal sand in the cortex. The vains are embedded and are not provided with bundle-sheaths. Veins of the mid-rib are vertically transcurrent above and below by collenchyma in *O. aspera*.

The hairy covering on the leaf and axis in *S. hispida* (figs. 160, 161) consists of articulate uniseriate trichomes with the terminal cell ending in a sharp point ; trichomes on the axis are situated in groups on the wiug-like ribs at the angles (fig. 161). Trichomes are more numerous on the lower surface of the leaf. Clothing hairs are absent on the leaf of *O. aspera* ; on the axis, however, there are peculiar dome-like unicellular hair-like structures with walls thickened and muriculate. Glandular hairs are not found on the leaf and axis.

Structure of the Axis.—The epidermis consists of tabular cells with outer walls greatly thickened. The outer walls are muriculate and the inner walls also thickened in *O. aspera* (fig. 162). The lateral walls are thin and straight. There are large wing-like ribs at the angles of the axis in *S. hispida*. The cortex of *S. hispida* is composed of parenchymatous assimilatory tissue extending into ribs which are strengthened by collenchyma. Assimilatory cells contain rounded bodies of the nature of fat bodies. Endodermis is differentiated. Sclerenchymatous pericycle is found only in *S. hispida* and is composed of a loose ring of bast fibres.

The vessels are arranged in complete rows and are larger in the lower half of the wood. Interfascicular wood prosenchyma is scantily developed and is formed of cells with thin walls and with large lumina. Medullary rays are uniseriate and numerous. The abundance of vessels and the scanty development of interfasicular wood prosenchyma are characteristic of the herbaceous nature of the plants.

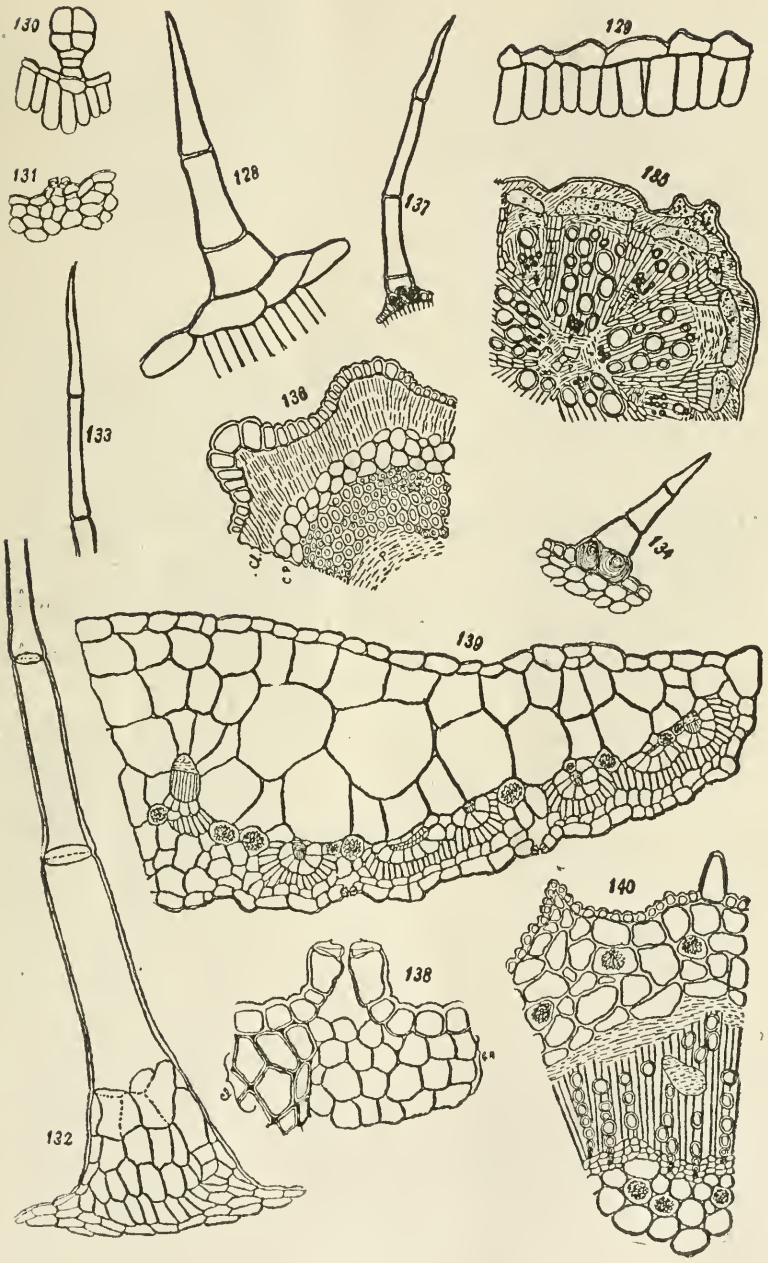
The pith is composed of thin-walled cells.

(*To be continued.*)

Plate XV

128-131. *Momordica dioica.*
128. Hair on the leaf.
Oc. 4 Com.; Ob. 3 mm. Ap.
129. T. S. of the leaf showing the upper epidermis.
Oc. 4 Com.; Ob. 3 mm. Ap.
130. Glandular hair on the leaf.
Oc. 4 Com.; Ob. 3 mm. Ap.
131. Stoma on the lower surface of the leaf.
Oc. 4 Com.; Ob. 3 mm. Ap.
132-134. *Cucumis Melo.*
132. Lower portion of the hair on the axis removed by peeling off the epidermis.
Oc. 2 Com.; Ob. 8 mm. Ap.
133. Terminal portion of the same hair.
Oc. 2 Com.; Ob. 8 mm. Ap.
134. Hair on the leaf.
Oc. 6 Com.; 8 mm. Ap.
135-136. *Citrullus Colocynthis.*
135. T. S. of the axis.
Oc. 2. Com.; Ob. 16 mm. Ap.
136. T. S. of the axis showing the ribs.
Oc 2 Com.; Ob. 3 mm. Ap.
137-138. *Melothria maderaspatana*
137. Hair on the leaf.
Oc. 2 Com.; Ob. 8 mm. Ap.
138. Stoma on the axis.
Oc. 6 Com.; Ob. 3 mm. Ap.
139-140. *Trianthema triquetra.*
139. T. S. of the leaf representing half of the leaf-blade including the mid-rib.
Oc. 4 Com.; Ob. 8 mm. Ap.
140. T. S. of the axis.
Oc. 6 Com.; Ob. 8 mm. Ap.

N.B.—To get the original dimensions multiply by 1·7.



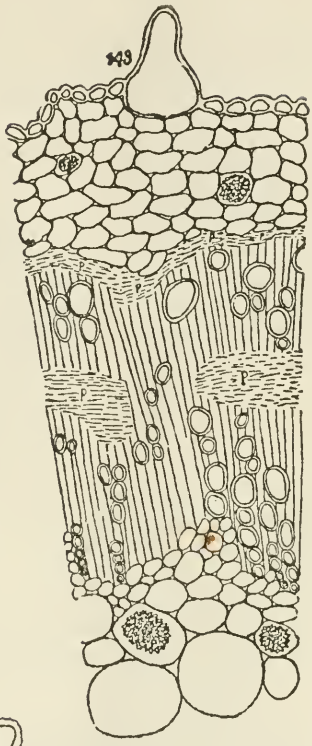
T. S. Sabnis del. PLATE XV.

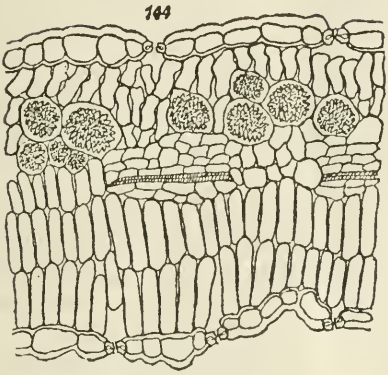
Plate XVI

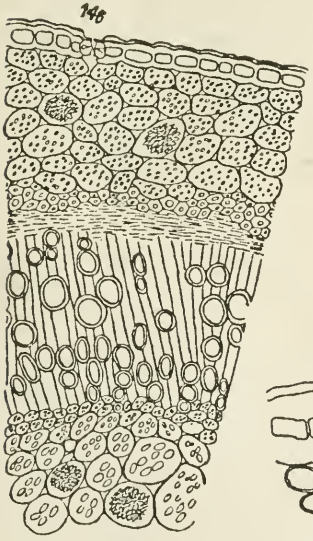
141-143. *Trianthema pentandra.*
141. T. S. of the leaf.
Oc. 2 Com.; Ob. 3 mm. Ap.
142. T. S. of the leaf showing the enlarged epidermal cells.
Oc. 6 Com.; Ob. 8 mm. Ap.
143. T. S. of the axis.
Oc. 6 Com.; Ob. 8 mm. Ap.
144-147. *Orygia decumbens.*
144. T. S, of the leaf.
Oc. 6 Com.; Ob. 8 mm. Ap.
145. Stoma on the axis.
Oc. 6 Com.; Ob. 3 mm. Ap.
146. T. S. of the axis.
Oc. 6 Com.; Ob. 8 mm. Ap.
147. Stoma on the leaf.
Oc. 6 Com.; Ob. 3 mm. Ap.
148. *Mollugo hirta.*
Hair on the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.

N.B.—To get the original dimensions multiply by 1·7.



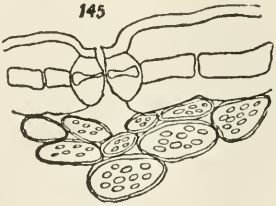












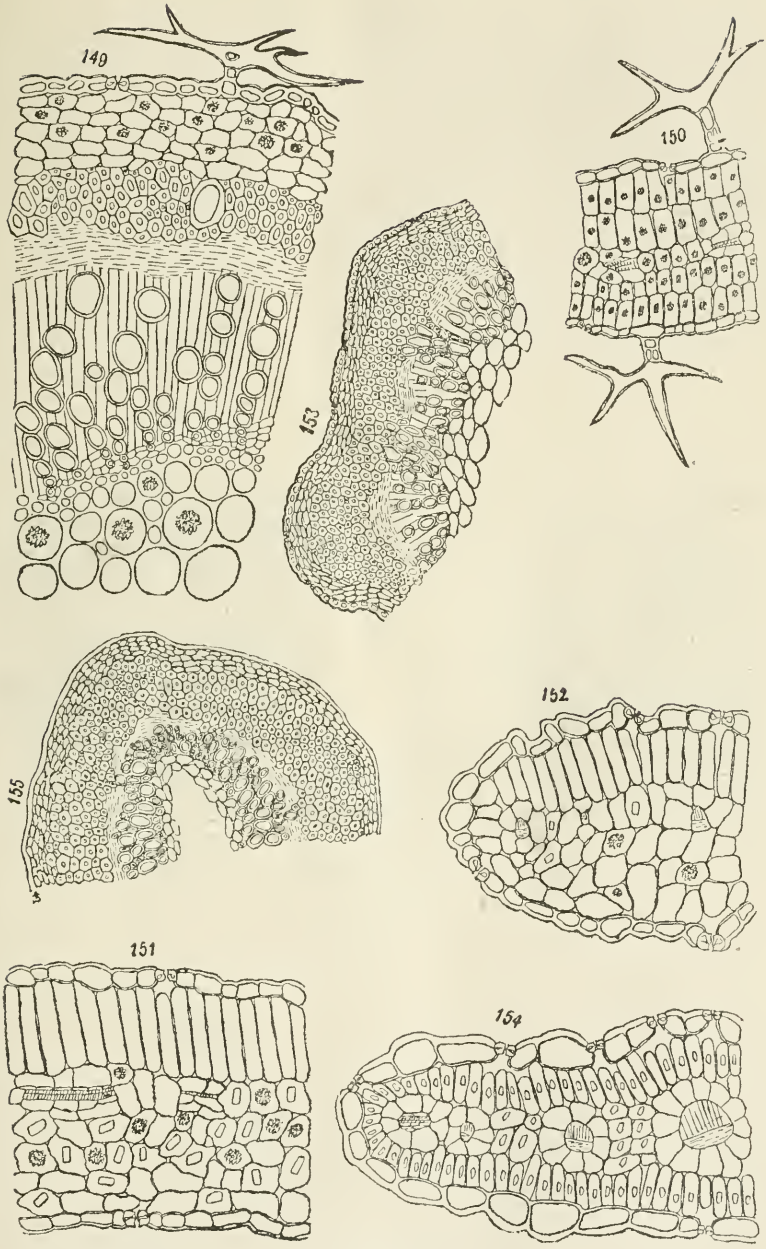


T. S. Sabnis del. PLATE XVI.

Plate XVII

149-150. *Mollugo hirta.*
149. T. S. of the axis.
Oc. 6 Com.; Ob. 8 mm. Ap.
150. T. S. of the leaf.
Oc. 2 Com.; Ob. 3 mm. Ap.
151-153. *Mollugo nudicaulis.*
151. T. S. of the leaf between the mid-rib and the margin.
Oc. 4 Com.; Ob. 3 mm. Ap.
152. T. S. of the leaf near the margin.
Oc. 4 Com.; Ob. 3 mm. Ap.
153. T. S. of the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.
154-155. *Mollugo Cerviana.*
154. T. S. of the leaf representing half the leaf-blade including the midrib.
Oc. 6 Com.; Ob. 8 mm. Ap.
155. T. S. of the axis representing half the axis.
Oc. 2 Com.; Ob. 3 mm. Ap.

N.B.—To get the original dimensions multiply by 1·7.

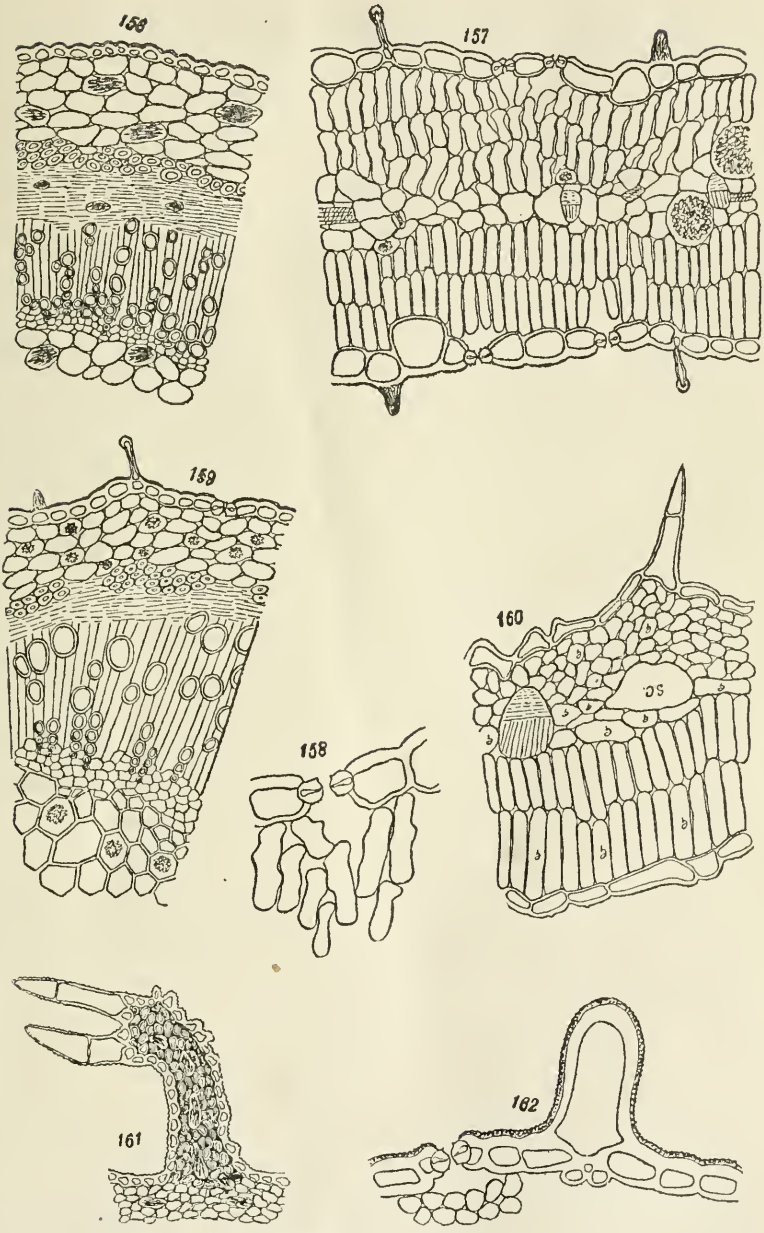


T. S. Sabnis del. PLATE XVII.

Plate XVIII.

156. *Gisekia pharnaceoides.*
T. S. of the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.
157-159. *Limeum indicum.*
157. T. S. of the leaf.
Oc. 6 Com.; Ob. 8 mm. Ap.
158. Stoma on the leaf.
Oc. 4 Com.; Ob. 3 mm. Ap.
159. T. S. of the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.
160-161, *Spermacoce hispida.*
160. T. S. of the leaf.
Oc. 4 Com.; Ob. 3 mm. Ap.
161. T. S. of the axis showing the wing-like rib bearing hairs.
Oc. 6 Com.; Ob. 8 mm. Ap.
162. *Oldenlandia aspera.*
T. S. of the axis showing the dome-like hairy outgrowth
Oc. 4 Com. Ob.; 3 mm. Ap.

N.B.—To get the original dimensions multiply by 1·7.



T. S. Sabnis del. PLATE XVIII

A CONTRIBUTION TO THE ECOLOGY OF THE UPPER GANGETIC PLAIN

By Winfield Dudgeon,

Ewing Christian College, Allahabad.

Introduction.

There is little published information about the ecological relations of the vegetation of the Upper Gangetic Plain. In their monumental survey and summary of the vegetation of India, Hooker and Thomson (4) have little to say of this area. They state that there are no forests except at the base of the Himalayas, and that uncultivated tracts are usually covered with loose " bush-jungle ". As every writer must do, they call attention to the markedly periodic climate. Schimper (10) concludes that a rainfall below 90 cm. per annum produce " xerophilous scrub ", while above that amount produces " xerophilous woodland ". Allahabad has a mean annual rainfall of very nearly 90 cm., but the connection of the vegetation with some type of a Schimper climatic climax is not so obvious.

The Upper Gangetic Plain, comprising roughly the United Provinces, is a very distinct ecological area. Eastward it passes into the much more humid climate of Bengal; southward it merges into the hilly regions of the Vindhias, where the climate is similar but the vegetation is distinct; westward it passes into the drier Panjab; and northward it is abruptly limited by the Himalayas. The rainfall diminishes westward, and increases northward and rapidly eastward. The climate is continental, with great range between winter and summer and between day and night.

This study is restricted to a small area about ten miles in radius with Allahabad at the center. Such a restriction is chosen because I am more familiar with this limited area, and because it is quite representative of the much larger area of the Upper Gangetic Plain.

Physical features of the area.

Allahabad is situated at 25° 26′ N. Latitude and 81° 52′ E. Longitude, at the southern edge of the great plain of the Ganges and Jamna Rivers, at their junction. The Meteorological Observatory is 319 feet above mean sea level, and this may be taken as approximately the level of the surrounding plains. The soil (9) is all alluvial, deposited within recent geological times. It ranges from sand, through a mixture of sand and clay, to fine clay. The older alluvium often contains deposits of calcium carbonate in irregular nodules, locally called

"kankar". Both rivers have been depressed in the recent past, so that even the highest floods no longer inundate the surrounding plains. In the immediate flood-plains of the rivers there are limited patches of quite modern alluvial deposits, which are subject to redistribution when the streams are in flood. Near the rivers, and especially the Jamna, there are often deep ravines with precipitous sides, formed as the result of rapid erosion during the short monsoon season. During the rest of the year they are stable.

Except where dissected by these ravines, the surrounding plains are monotonously level. Here and there are slight natural depressions which become shallow lakes during the rainy season, but which are dried up later by evaporation, and by use of the water for irrigation purposes. There are very numerous artificial pools, made for collecting a supply of water to be used for irrigation during the winter and spring. Some of them are deep enough and extensive enough that they retain some water throughout the year. Lastly, there are a very few deeper and more permanent bodies of water created by damming up ravines. Some of the larger natural depressions catch the drainage sufficiently large area to accumulate considerable amounts of salts, chiefly sodium sulphate, mixed with more or less sodium chloride and sodium carbonate, and hence become "alkali", known locally as "usar". Aside from variations in the amount of water present, and from the deposits of usar, the soil of the plains presents a very uniform substratum for the growth of vegetation.

The factors influencing and determining the vegetation.

Climatic factors usually are considered to be the most important factors in the ecology of an area, but in the Upper Gangetic Plain biotic factors are at least of equal importance. The climatic differ only in degree from those met with in other parts of the world. The climate is characterized by striking periodicity. No interpretation of the vegetation can be complete without due consideration of the biotic factors, of which the most important are the very dense agricultural population, and other factors associated with a crowded population.

1. The climatic factors.

The climatic factors that appear to be of greatest importance are rainfall, insolation, temperature, humidity, and air movements. These factors are so distributed as to result in a strongly periodic climate. The data I have made use of are mostly taken from the records of hourly observations at the Allahabad Meteorological Observatory (5), extending over a considerable number of years.

Rainfall. The mean annual rainfall for Allahabad, calculated in 1913 (7), is 37·54 inches; other calculations put it as high as 40 inches. The distribution of this fall is indicated in Table I and Fig.

Table I

——	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Rainfall ...	0.82	0.45	0.23	0.16	0.07	4.14	11.25	10.54	5.10	2.52	0.31	0.14
Per cent. ...	2.3	1.3	0.6	0.4	0.2	11.6	31.5	29.5	14.3	7.1	0.9	0.4

Mean monthly rainfall in inches, and percentage for each month, for Allahabad.

From this table it will be seen that 94 per cent. of the rainfall occurs during the months of June to October, while only about 1 per cent. falls during March, April, and May. The rainfall is remarkably uniform from year to year (8). In 44 years a deviation of 33 per cent. or more above normal has been observed but seven times, and a corresponding diviation below normal but six times. The greatest recorded rainfall was 76·25 inches in 1894, and the lowest 16·82 inches in 1864.

During the monsoon the rains are at times torrential, at other times gentle and lasting for one or more days. The soil is baked hard by the intense heat and drought of spring, and wherever drainage has been established the more violent rains quickly run off. Under such conditions erosion is heavy, and the soil is wet only to a slight depth. After unusually heavy rains the level areas become vast shallow seas; one may travel for miles along the railways and see no land except the railway embankment and the mounds on which villages are situated. Water is retained in the shallow depressions, from which it disappears at length by evaporation and by use for irrigation. In consequence, where there is good drainage there is little accumulation of water in the soil, but where drainage is poor, the soil, or at least the surface soil exploited by plants, is saturated.

Insolation. Little has been done with this climatic factor. The Meteorological Observatory has kept hourly observations of cloudiness, using the usual scale of 0—10, where 0 indicates a cloudless sky, and 10 indicates the sky completely overcast by dense clouds or low fogs. Such a record is necessarily a matter of judgment, and is of no great value in the study of climatic factors. We have nothing to indicate what proportion of the solar energy is in the form of

heat, what in the form of visible light, and what ultra-violet. Table II shows the observed records of mean cloudiness, based on hourly observations extending over a number of years; these same records are plotted in graphical form in Fig. 3.

Table II

—	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
—	1 6	1.8	1.9	1.6	1.7	5.0	7.4	6.7	4.1	2.0	0.7	0·8

Mean monthly cloudiness on the scale of 0—10, for Allahabad.

Clouds become common in June, perhaps two weeks before the rains actually begin. June to September are the cloudy months. In June there are densely cloudy days interspersed with days of burning sunshine. During July and August the clouds are denser and more persistent, but even then there are breaks when the sun shines from a nearly cloudless sky with the intensity of the dry season. From September on the number of sunny days gradually increases, till in November the sky is cloudless or overspread with only thin hazy clouds for weeks at a time. This is broken at some period during December, January or early February by the "winter rains", when for a short time monsoon rains are repeated on a miniature scale. During most of the time from the end of the rains to the beginning of the next monsoon the sun shines down with unbroken violence, accentuated during March, April, and May by low humidity.

Temperature. The climate of the Upper Gangetic Plain is distinctly continental. The nearest large body of water is the Bay of Bengal, more than 400 miles to the eastward. The temperature accordingly exhibits a large range between winter and summer, and between day and night, despite the fact that Allahabad is barely outside the tropics. The lowest temperature occurs in December, when the mean is 59.0° F.; January is 0.3° warmer. From then on there is rapid rise to a maximum of 91.6° F. in May and June. The high point that should be reached in June and July is prevented by the increasing cloudiness of June, and the following monsoon. In July the mean temperature is 84.4°, falling to 83.0° in September. Here what would be the normal descending curve is met again, and the fall is rapid to the 59.0° of December. Table III shows the temperature in degrees Fahrenheit by months for the year (see Figs. 1 and 3).

Table III

—	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Mean maximum ...	73.4	79.8	92.9	102.6	104.4	99.6	89.2	89.3	90.3	88.0	81.2	74.2
Mean ...	59.3	64.9	77.8	87.6	91.6	91.6	84.4	84.1	83.0	76.2	66.3	59.0
Mean minimum ...	49.2	52.5	64.1	73·4	79.6	85.1	80.4	80.0	77.4	67.6	56.1	48.6
Mean daily range.	24.2	27·3	28.8	29.2	24.8	14.5	8·8	9.3	12.9	20.4	25.1	25.6

Mean, mean maximum and mean minimum temperature, and mean daily range, in degrees Fahrenheit, by months, at Allahabad.

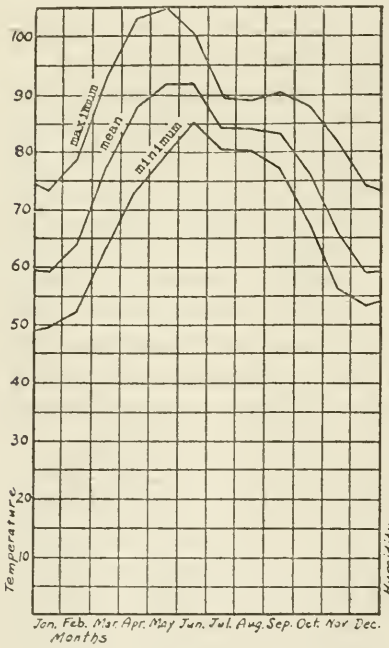


Fig. 1

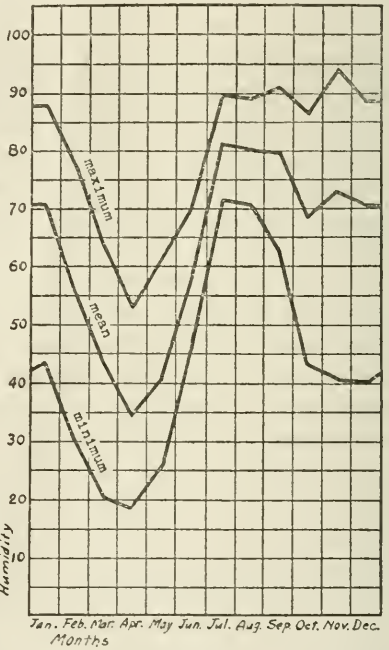


Fig. 2

Fig. 1. Mean, mean maximum and mean minimum temperature in degrees Fahrenheit for the year at Allahabad.

Fig. 2. Mean, mean maximum and mean minimum relative humidity in per cent. for the year at Allahabad.

The daily range of temperature is large throughout most of the year (Table III). During the monsoon it reaches a minimum of 8.8° F. in July, then rises through the autumn and winter to a maximum of 29.2° in April; from here it falls again rapidly to July. The period of maximum daily temperature range coincides roughly with the period of highest absolute temperature.

Such temperatures as the above means alone would not be unfavorable for plants; it is the occasional extremes that make plant growth difficult. The mean annual extremes range from 39.6° to 114.9° F. On rare occasions the temperature of a winter night may drop down to or below the freezing point, but apparently these exceptional low temperatures are of little importance in determining either the character or the composition of the vegetation, even in depressions where frost is most liable to occur. The highest recorded temperature was 119. 8°F., on June 19, 1878 (8). It is the occasional unusually high temperature during the hot season, together with low humidity and a strong wind, that makes plant life difficult.

The temperatures given above were taken under open thatched sheds, at a height of 4 feet from the ground. The temperature at the soil surface at times rises very much higher than these figures (6) "The average temperature of the ground surface in India is, at the hottest time of the day in the cold weather from 10° to 20° (F.) above that of the air at 4 feet high. The difference increases until the months of April and May, when the excess is usually as high as 40° and sometimes 45° or 50° (F.)". It falls rapidly during the rainy season, and is as small in August as in the cold season.

Humidity. Temperature and humidity seem to be the most important of the climatic factors influencing plant development. Perhaps humidity is the most important, for if the proper balance between water loss and water intake could be maintained, plants would be able to endure without much difficulty the maximum temperatures of the Gangetic Plain. In general, humidity depends on rainfall, but during the cold season the low temperature is an important factor in increasing the relative humidity.

From a mean of 70.4 per cent. in January, the relative humidity falls rapidly to a minimum of 34.7 per cent. in April, then rises rapidly to a maximum of 81.9 per cent. in July. There is a slow fall to 80.2 per cent. in September, then it becomes rapid with the cessation of the rains, down to 68.9 per cent. in October. Here it is overtaken by the falling temperature, and rises to 72.9 per cent. in November, and 70.5 per cent. in December and January. With the rapidly rising temperature and low rainfall of the hot season it falls very rapidly to the April minimum. See Table IV and Figs. 2 and 3. The periods of high relative humidity are optimum for plant growth. As in the case of high temperature, it is the periods of low humidity that cause trouble. The daily humidity range is great during most of the year. Maximum humidity usually occurs at about 6 o'clock, and minimum at about 14 o'clock. July shows the least daily range

and November the greatest, though the range is great throughout the cold season. The daily range during the hot season is intermediate.

Table IV

—	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Mean maximum ...	88.2	76.5	63.7	53.2	61.5	70.4	89.6	89.3	91.3	86.4	94.1	88.6
Mean ...	70.4	55.6	43.2	34.7	41.4	58.6	81.9	80.5	80.2	68.9	72.9	70.5
Mean minimum ...	43.5	30.9	21.0	18.4	25.2	45.4	71.7	70.1	63.9	43.4	40.7	40.5
Mean daily range ...	44.7	45.6	42.7	34.8	36.3	25.0	17.9	19.2	28.4	43.0	53.4	48.1

Mean, mean maximum and mean minimum relative humidity, and mean daily range, in per cent, by months, for Allahabad.

The mean relative humidity by months gives a very inadequate picture of the severe conditions to which plants are subjected in the hot season. During April, for example, the mean is 34.7 per cent. but the mean minimum attained about 14 o'clock, is 18.4 per cent. and there are many days when the extreme runs much below this ; even at night the mean maximum is only 53.2 per cent. During the rainy season humidity is generally high, and at all times very favorable for plants. During the cold season the mean maximum attains the highest point for the year, reaching 94.1 per cent. in November. Night after night there is a havy fall of dew. At the same time the daily range is greatest during this period, the 14 o'clock mean minimum dropping to 40 per cent. The humid nights permit the vegetation to recover from the drought of daytime. During the hot season, however, there is little opportunity for recovery following the extremely dry day, and none but the most xerophytic of the herbaceous plants are able to survive this trying period.

Wind. The wind is an important climatic factor in two distinct ways : by bringing in moisture during the rainy season ; and by accentuating the aridity of the hot season. In the latter case only the air currents near the earth are of importance. During most of the year the winds blow fitfully, with a large percentage of the time calm. During March, April and May, wind becomes a very important factor influencing vegetation. Beginning about 11 and continuing till 16 or 17 o'clock, there is a strong wind from the N.N.W., locally known as the "lu." Coming as it does at a time when the relative humidity is at the lowest point, it exerts a powerful dessicating effect on vegetation. The soil is dried out by wind and heat together, and little herbaceous vegetation that is not protected, or favorably situated with regard to water supply, is able to survive. There is little or no air movement at night during the hot season.

Climatic seasons. From the foregoing it will be seen that the climate is markedly periodic, and divides quite naturally into three

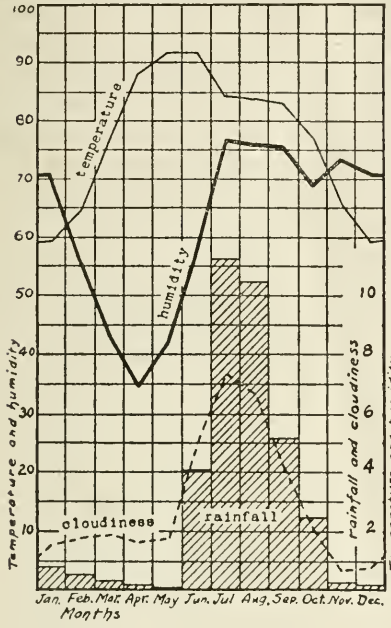


Fig. 3

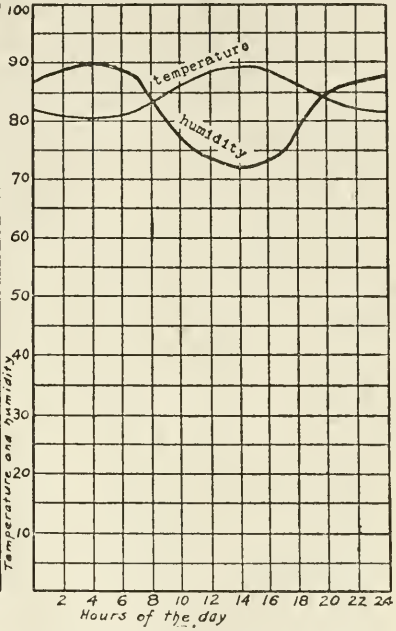


Fig. 4

Fig. 3. Mean temperature in degrees Fahrenheit, mean cloudiness on the scale of 0—10, mean rainfall in inches, and mean relative humidity in per cent. for the year at Allahabad.

Fig. 4. Mean hourly temperature in degrees Fahrenheit and mean relative humidity in per cent. for the month of July at Allahabad.

seasons : a Rainy Season ; a Cold Season ; and a Hot Season, (Fig. 3). Corresponding with the climatic seasons there are three distinct

Table V

Hours of the day	2	4	6	8	10	12	14	16	18	20	22	24
APRIL												
Temperature ...	76 9	74.6	73.4	84.2	94.9	100.1	102	101 6	95.0	86.4	82.4	79.6
Humidity ...	46.5	50.6	53.2	38.9	26.6	21 2	18.4	18 7	25.5	34.8	40.1	43 0
JULY												
Temperature ...	81.5	80.6	80.6	83.1	86.2	88.1	89.2	88.4	86.5	83.8	82.7	82.2
Humidity ...	88.1	89.3	88.8	83.8	77.6	73.9	71.7	73.0	77.4	84.7	86.2	87.3
DECEMBER												
Temperature ...	51.0	49.7	48.6	52.6	63.5	71.6	74.2	71.8	61.2	57.4	54.7	52.7
Humidity ...	85.5	86.7	88.4	80.8	57.6	45.1	40.5	46.4	70.9	76.8	81.2	83.3

Hourly mean temperature in degrees Fahrenheit and mean relative humidity in per cent., on the even hours, for the months of April, July and December, at Allahabad.

vegetational seasons. From the point of view of the vegetation it is convenient to begin the year with the rainy season (Fig. 7). This season may be taken to begin about the 15th to the 20th of June, when the first scattering rains fall, and lasts to the end of September. It is characterized by high rainfall, low insolation, high temperature, and high humidity (Table V, and Figs. 4 and 7). July may be taken as typical of this season, when the mean temperature range is from 80.6° to 89.2°F., while the relative humidity ranges from 89.3 to 71. 7 per cent. Such conditions are optimum for plant growth, and a luxurient herbaceous vegetation springs up.

The rainy season merges gradually into the cold season, which may be taken to extend from the first of October to the end of February. It is characterized by low rainfall, high insolation, low temperature, and relatively high humidity. December may be chosen as a typical month; the mean temperature range is from 48.6° to 74.2°F., and the relative humidity runs from 88.4 to 40.5 per cent. (Table V, and Figs. 5 and 7). The lower temperature and the low

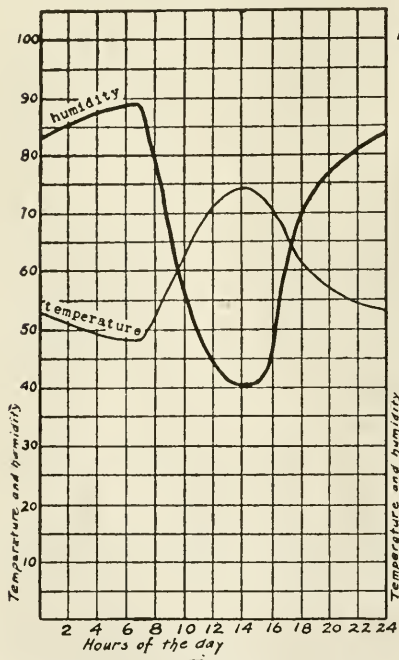


Fig. 5

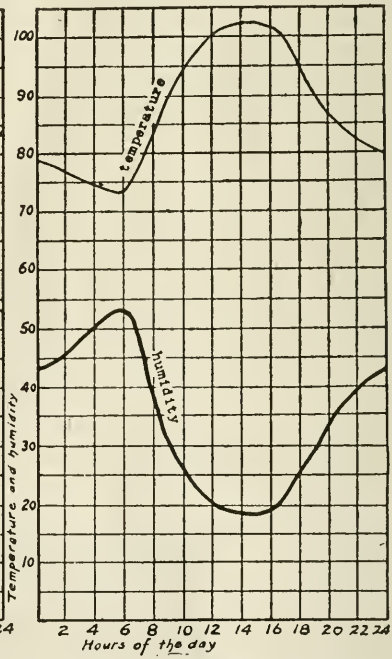


Fig. 6

Fig. 5. Mean hourly temperature in degrees Fahrenheit and mean relative humidity in per cent. for the month of December at Allahabad.
Fig. 6. The same for the month of April.

humidity of midday result in a vegetation that is mesophytic, and which contains a larger proportion of temperate region plants.

The hot season is ushered in with the rising temperature and decreasing humidity of spring, and extends from the first of March to the middle of June. It is characterized by low rainfall, high insolation, high temperature, low humidity, and strong winds. April and May are typical of this season. The April temperature ranges from 73.4° to 102.6° F., and the humidity from 53.2 to 18.4 per cent. (Table V, and Figs. 6 and 7). Both temperature and humidity are

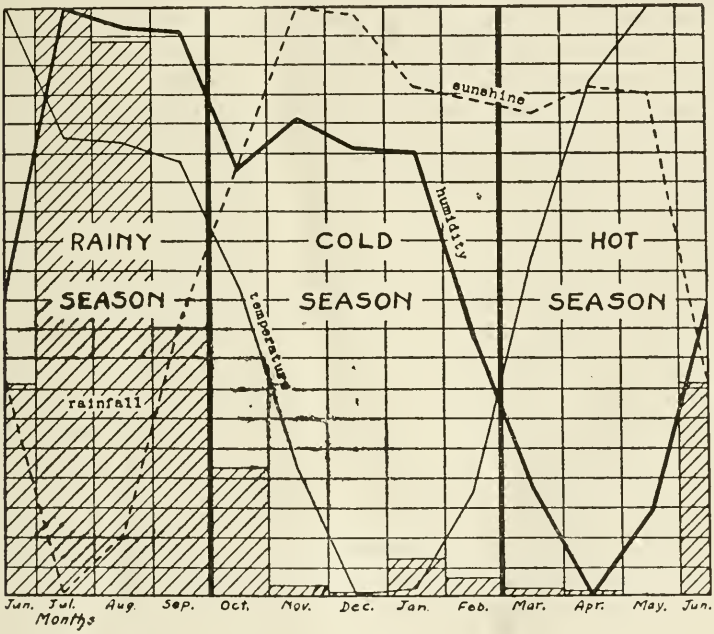


Fig. 7

Fig. 7. Mean temperature, mean sunshine (mean cloudiness curve inverted), mean rainfall, and mean relative humidity for the year at Allahabad, so calculated that all the maxima touch the top of the graph and the minima touch the bottom. This emphasizes the three climatic seasons, which determine three corresponding vegetational seasons.

slightly higher in May. The climatic conditions are distinctly xerophytic, with the result that the mesophytic vegetation of the cold season disappears, and only those plants that are adapted to withstand the severe drought can survive. There are limited local areas that for some reason or other are able to supply sufficient moisture to sustain mesophytic plants, and it is in such places only that the vegetation remains distinctly green.

2. The biotic factors.

The term "biotic factors" includes all influences traceable to living organisms, but only animals and man are considered in this paper. Undoubtedly man and his domesticated animals are the most important of the biotic factors. For more than 20 centuries the Gangetic Plain has been populated with an agricultural people. It is difficult and perhaps impossible to form any adequate conception of the intensity of the human factor in times past, but since 1850 the population of the 2811 square miles of Allahabad District has fluctuated from 480 to the high level of 543 to the square mile at the 1891 census (8). At present it is about 530 per square mile. To the human population must be added, according to census of 1909, 331 cattle and buffaloes, 123 sheep and goats, and 8 horses and donkeys, or a total population of domestic grazing animals of about 463 per square mile. Therefore the area has to support a total population of about 1,000 per square mile of animals that gain most or all of their food directly from the vegetation.

Man influences the vegetation in a number of ways, mainly by cultivation, by grazing his animals, and by cutting for food and fuel.

Cultivation. The returns of 1907-08 (8) show that about 58 per cent. of the District was under cultivation. This figure probable fairly indicates the extent of cultivated land from year to year in the area immediately surrounding the city of Allahabad. Cultivation causes retrogression of the vegetation, and the more thorough it is, the greater the effect. Wild plants, both annuals and perennials, are rooted up and killed, and their place is taken by annual ruderals, usually native, but in many cases introduced. At the same time cultivation tends to make the area more xerophytic by removing the permanent plant covering, and substituting a cover of perhaps more mesophytic but short-lived annuals. When the crop cover is harvested the soil is left practically bare, and dries out speedily.

Grazing animals. All of the uncultivated land in the area is closely grazed throughout the year. During the rainy season, the vegetation is able to keep pace with grazing, even though it is constantly kept eaten off close to the ground. As the cold season progresses and the growth of herbaceous vegetation is checked, the effect of overgrazing become more and more evident. Finally, during the dry season all grasses and associated plants are eaten down to the soil surface (Fig. 11). Annuals die under the combined hardships of the grazing and lack of protection. Only perennial grasses and a few other xerophytic herbs with strong perennating organs are able to survive. Where overgrazing progresses still further, even the peren-

nial grasses are destroyed, and the ground left practically bare (Fig. 14).

In consequence of the severe grazing there is no cover of vegetation on the ground to aid in conservation of the monsoon rains. Where drainage has been established, runoff of the monsoon rainfall is very rapid and complete; where the land is flat, the vegetation has no effect in preventing runoff.

The scattering thorny shrubs and small trees, with a few inedible exceptions, are kept eaten done to small dense rounded bushes wherever and as long as animals are able to reach them.

Cutting for food and fuel. In India a very large proportion of the plants comprising the flora is made use of by man for some specific purpose, especially for food and medicines. Perhaps the results of all such exploitation are not in the longrun very detrimental. Usually it is parts that are not essential to the life of the plant that are used for food. It is for forage and fuel that man works the greatest havoc with the vegetation. Throughout the year, and especially during the hot season, much of the available grass covering is cut off just below the surface of the soil for fodder for domestic animals. It is only the most persistent perennials that can survive such treatment. In the Upper Gangetic Plain no natural fuel remains except a few species of xerophytic shrubs and small tress, and in most places these are periodically cut, sometimes almost to the extinction point. The fine groves about villages are all planted, and these alone escape the unremitting struggle of man to find fuel. There is no attempt locally at conservation of plant resources.

Wild fires are negligible as a factor influencing vegetation, for the reason that the land is so intensively cultivated and grazed that there is nothing left to burn.

Wild grazing animals are not numerous and are of little importance. Earthworms are abundant during the rains, and their burrows probably are of considerable importance in promoting aeration and water penetration. Numerous species of black ants probably render a similar service. In general, insect pests are relatively unimportant. It is uncommon to find the indigenous vegetation eaten to any great extent.

White ants. White ants are the only insects that exert any great influence on the vegetation. They are found everywhere and are almost unbelievably abundant. Doubtless their burrows function as do those of the black ants, and they reach a depth of 5 feet or more. It is only rarely that white ants attack living plants, though they closely follow dieing parts and keep them eaten away. When grasses and other plants, especially the annual vegetation, die, the

white ants eat the remains. The great problem in this connection is whether and to what extent they prevent the accumulation of this dead vegetation as organic matter in the soil. It may be that the intense heat and dryness of the hot season would oxidize organic matter even if it were introduced into the soil, though the experience from trenching indicates that this is not necessarily the case. It is probable that the organic matter eaten by white ants is oxidized within their bodies. This prevents the usual course of oxidation by the action of bacteria in the soil with the resulting increase of nitrates and solution of mineral constituents, and the soil is deprived of just so much fertility. In so far as they prevent the accumulation of organic matter in the soil, and thus impair its fertility and water-holding capacity, white ants are detrimental to the vegetation.

Almost literally every square inch of ground is either cultivated or grazed. Excessive grazing is by far the most important of the local biotic factors. It becomes increasingly evident that there can be no adequate interpretation of the vegetation of such an area as the Upper Gangetic Plain without due consideration of the tremendous pressure of the human factors. Neither climatic nor biotic factors alone, but all acting together, influence and determine the vegetation.

Ecological features of the vegetation.

Types of succession. It is well established that under natural conditions the vegetation of new local areas, such as ponds, stream margins, cliffs, bare rocks, cultivated tracts, and the like, passes through a succession of associations, finally culminating in a permanent climatic climax. COWLES (3) distinguishes two types of succession in any given region :— (1) Climatic, depending on slow changes in geologic climate, and which is at all times in the stage of climatic climax ; and (2) Topographic, occurring as smaller cycles of development within the immensely large climatic succession, and dependent on local physiographic variations. The climatic succession progresses so slowly that it cannot be made the subject of exact study. Topographic succession progresses much more rapidly, but still is a slow process. It usually is assumed that the associations observed in passing from a new area to the climax fairly represents the succession as it occurs at any given spot through a long period of years. Each topographic succession area has as its goal the climatic climax vegetation, and is terminated when this stage is attained.

Seasonal succession. A third type of succession is a prominent feature in a strongly periodic climate. It is illustrated by the

striking changes in the aspect and content of the vegetation from season to season, and may be called seasonal succession. As a result of the three well defined climatic seasons, rainy, cold, and hot, there are three equally well marked vegetational seasons. The traveller across the Upper Gangetic Plain is impressed with the numerous groves of stately trees. These groves are without exception planted, and are composed of species that either are not native to the immediate area, or that cannot survive in the young stages without protection. Some of these trees would quite readily perpetuate themselves were it not for the pressure of the human factors.

Aside from cultivated fields and the groves of planted trees, the aspect of most of the area is determined by herbaceous plants. Here and there are tracts dominated by shrubs and small trees, but across these the herbaceous vegetation extends unchanged. Obviously there is no change in the content of the woody vegetation in response to change in season, but there is response in the matter of leaf fall and time of blooming. Even these changes are relatively inconspicuous in comparison with the changing aspect of the herbaceous and undershrub vegetation. It is periodicity in the small and very abundant annual and perennial plants that renders the fact of seasonal succession so conspicuous.

During the rainy season, when all conditions are favorable for maximum plant growth, the whole country is covered with a luxurient mantle of herbaceous vegetation. Much of it is annual. The perennial herbs and undershrubs attain their maximum development at this time. The vegetation approaches hygrophytic, with large soft thin leaves and tender stems. It is during the rainy season that the tropical aspect of the flora as well as its composition appears most clearly.

With decrease of rain, and the lower temperature of the cold season, much of the rank growth of the rainy season disappears. What survives is gradually eaten down by grazing animals. The hygrophytic annuals are replaced by mesophytic annuals, especially Compositae, of more temperate connections. Perennials lose their luxurient tropical appearance, and in every way the vegetation is less in amount, number of species, and conspicuousness.

With the advent of the hot season, the high temperature and extreme aridity complete the destruction of the annual vegetation that is not situated in favored edaphic spots, and little more than the persistent perennials remain. There are a few annuals, but the number is small. The perennials now present a very different appearance from that of the rainy season, and even the cold season. All but the youngest leaves fall, and the more deli-

cate branches die. The hard resistent parts remain alive, and continue to put out a few new leaves and bloom profusely throughout this season. The herbaceous vegetation is characterized by well developed perennating organs. Prostrate and rosette forms abound. Much of the soil surface is exposed, and a pall of impalpable grey dust settles over everything. Both in aspect and structure the vegetation is distinctly xerophytic.

The vegetation of the cold season is more representative than at any other time of the year. Besides the many plants peculiar to this season, some of the more hardy of the rainy season annuals persist, and the vegetation exhibits a freshness and vigor that is lacking in the hot season. The outstanding features of succession are also more obvious at this time.

The influence of man on the vegetation. It is impossible to determine what was the condition of the vegetation in the Upper Gangetic Plain before the interference of man. Doubtless many plants have been directly exterminated, and others have been killed by removal of some sort of protecting forest cover ; others have been eliminated in competition with plants introduced along with man, and by the changed conditions resulting from his various activities. But man has been present long enough, and has maintained his conditions of living sufficiently unchanged that the vegetation has become balanced against him. With the awakening in agriculture, the human factors are beginning to change, and in consequence we may expect more or less profound changes to take place in the vegetation again. The effect of the human factors is to interfere with the natural development of the vegetation, and to throw it back to a more primitive stage. If the human factors about Allahabad where to become much more intense, there would result the extinction of many valuable native plants, and a further regression in the vegetation ; if the human factors where to relax in intensity, the vegetation would at once pass on to a more advanced stage ; if man were removed entirely the vegetation would ultimately reach a climatic climax, though different in detail from the one present when man first arrived on the scene in significant numbers. This balance between the progressive tendencies of the vegetation and the retrogressive influence of man is one of the most striking features of the local vegetation.

Not only has man caused the vegetation to retrogress from the original climax, and is now in a state of balance with it, but he interferes with normal succession in edaphic areas so profoundly that it may actually be prevented. Pools, for example, that should show early stages in succession, serve as bathing places for man and beast,

as the village water supply and laundry, as the village sanitary system, and finally as a source of water for irrigation. Ponds that appear promising places for study one year are devastated the next (Fig. 9). The result is that for the most part succession must begin as the beginning each year. Instead of the topographic succession, pools present year after year much the same appearance for a given season, and seasonal rather than topographic succession is conspicuous. This renders the study of topographic succession very difficult, and everywhere emphasizes the struggle that is going on between man and nature, and the balance that has become established between them. By far the largest part of the area is as far advanced in succession as is possible under existing conditions (Fig. 11).

Details of topographic succession.

In more favored parts of the earth where vegetation has a chance to develop naturally, it is possible to study with considerable precision the gradual develcpment of the flora from the most primitive conditions to the most advanced association of plants that the area can support. For the most part studies in plant succession have been made in temperate regions, where there is but one vegetational season, the summer or growing season. This is followed by a winter season during which the vegetation is at more of less of a standstill. In the Upper Gangetic Plain there is no season in which growth is impossible. Growth is checked and the vegetation modified by the aridity of the hot season, and at all seasons and at every stage it is interferred with even to the extinction point by the human factors. Therefore it is not an easy matter to trace the steps of topographic succession. The problem is further complicated by the seasonal succession. Yet in spite of the difficulties, it has been possible to find a few favorable spots which give a clue to the early stages of succession, and others which indicate what the higher stages would be if the human factors were lessened or removed.

Stages is the topographic succession. It is convenient to divide the succession into the following stages :—

1. Aquatic stage.
2. Wet meadow stage.
3. Dry meadow stage.
4. Thorn scrub stage.
5. Pioneer monsoon deciduous forest stage.
6. Climatic climax monsoon deciduous forest stage.

Of these stages the first is quite commonly observed in pools and streams ; the second is not well represented ; the third is the present modified climatic climax; stage four is not found well developed anywhere, but fragments of it are to be seen in protected places, and in the thorny shrubs and small trees scattered over certain areas ; stages five and six are largely hypothetical, and six would be the true climatic climax for this portion of the Gangetic Plain.

Aquatic stage. As has been said, the aquatic stage is to be found in the numerous pools that are scattered everywhere over the area. Most of these pools are very small and shallow (Fig. 9); a few may cover an area of several acres ; some dry up after the close of the rains, while others retain their water up into the cold season, and a few are permanent. The smaller and shallower and less permanent pools show only the earlier phases of the aquatic stage, for the natural vegetation is always interfered with by man. The constant use of a pool for various domestic purposes destroys most or all of the plants, and irrigation finally removes the water and leaves a mud flat that quickly dries out without being able to support much in the way of plant growth. The green plants in proximity to water are eaten off by grazing animals. Shallow pools are planted with rice during the rains (Fig. 9), and this effectively prevents development of the characteristic wild aquatic vegetation. The small number of native plants that can grow under such conditions are more of the nature of ruderals. Even if a pool is relatively free from human disturbance, the water level is rapidly lowered by evaporation, so that plants that are strictly aquatic during the rains are finally stranded on mud flats to dry out and die, or to survive by means of perennating organs till inundated during the next rainy season (Fig. 8.).

The aquatic stage may be further divided into :—

Free-floating aquatic stage ;
Attached submersed aquatic stage ;
Attached emersed aquatic stage.

These stages overlap each other more or less, but they indicate the actual order of normal succession.

Free-floating aquatic stage. This stage is represented mainly by algæ, of which there is great variety and considerable abundance. The principal algæ are several species of Cyanophyceae, *Spirogyra* spp., and *Cladophora* spp ; others very commonly found, but abundant only in very limited areas are *Mougeotia* spp., *Oedogonium* spp., *Hydrodictyon*, and *Vaucheria*. The Cyanophyceae are specially abundant in the shallow rainy season pools, though they are rather

common throughout the year. Various species of *Spirogyra* are to be found throughout the year. *Mougeotia*, *Hydrodictyon*, and *Vaucheria* are most abundant in later winter and the hot season.

There are a few free-floating aquatic vascular plants, the most important being *Ceratophyllum demersum* L., *Azolla pinnata*, *Lemna minor* L., *Wolffia arrhiza* Wimm. and *Trapa bispinosa* Roxb. The first named belongs primarily to the rainy season, the others mainly to the cold season.

Submersed attached aquatic stage. It is in this stage that the vegetation first becomes really abundant, and an important feature in succession. The plants of this stage root in the mud floor of the pool, and grow upward, though always remaining under water. Some of them growing in the rivers are attached many feet below the surface, and produce an enormous amount of vegetation. *Potamogeton pectinatus* L., is able to occupy the deepest water, and is one of the most abundant of the aquatics. *Hydrilla verticillata* Casp., *Naias graminea* Delile and *Vallisneria spiralis* L., are equally abundant, and are found in progressively shallower water. Others very commonly met with are *Potamogeton crispus* L., *Zannichellia palustris* L., *Chara* spp., and *Nitella* spp. Most of these plants are to be found throughout the year, though they reach their maximum development during the cold season. *Chara* and *Nitella* are not so abundant during the winter, because they are plants of shallow water, and are among the first to be destroyed by drying up of the pools.

Attached emersed aquatic stage. Plants of this stage are confined to rather shallow water (Fig. 8), and thus are very liable to be left stranded by lowering of the water level. Some of them are amphibious, and succeed in making fair growth even when exposed for long periods. The vegetative parts of others are killed by the exposure, and only subterannean perennating organs remain alive. The most important and characterestic plants of this stage, approximately in the order in which they appear in the succession, are *Nymphaea lotus* L., *Eleocharis plantaginea* Br., *Scirpus maritimus* L., and *Marsilia* sp. There is a number of other species that occur quite commonly, but are not present in large numbers, and take little part in giving character to the formation. A few characteristictly amphibious species root in shallow water, and produce extensive floating branches that grow out over the surface of the water (Fig. 9). Chief among these are *Ipomaea reptans* Poir., *Panicum paspaloides* Pers., and *P. punctatum* Burm. They never, however, are permitted to develop the dense floating mats that are so common a feature of aquatic vegetation growing under undisturbed conditions.

Wet meadow stage. This stage comprises the vegetation on the

margin of damp soil between the water of pools and the extensive dry meadows that characterize the plains. It is perhaps the most difficult stage of all to unravel, because its green vegetation forms such an attractive grazing ground, and because it shifts position with the change of seasons. During the rainy season it encroaches on the dry meadow, and during the hot season it recedes far toward the center of the pools, or disappears entirely. I have found just one place where the water relations are sufficiently constant that the wet meadow is permanent enough to study in detail (Fig. 10). By supplementing this small area with observations on other places, it is possible to give a fairly consistent account of the wet meadow stage.

The typical association is characterized by a large development of Cyperaceae and *Cynodon dactylon* Pers. About the pools that are subject to extreme fluctuation in water level there is also intensive cultivation and grazing (Fig. 9), and the Cyperaceae and *Cynodon* are about the only plants of consequence that can survive from year ot year. Many of these plants are able to adapt themselves to a wide range of conditions, from shallow water to relatively dry banks. *Cynodon dactylon*, for example, is specially typical of later stages of the wet meadow, yet it can grow fairly well when completely submerged, and persists in many places into all but the dryest of the dry meadows. The following is a list of the common plants of the wet meadow is arranged approximately in the order of succession : *Scirpus maritimus*, *S. quinquefarius* Ham., *Cyperus difformis* L., *Fimbristylis diphylla* Vahl., *Ammannia baccifera* L., *Ranunculus sceleratus* L., *Cynodon dactylon*, and *Eragrostis tenella* R. and S. Usually *Scirpus quinquefarius*, *Fimbristylis* and *Cynodon* determine the general aspect of this stage (Fig. 10).

Where the wet meadow zone shifts back and forth with the change of season, where erosion produces fresh soil surfaces, and where the human factors are very intensive, perennial plants are replaced by an association of short-lived annuals. These come up from seed whereever conditions are favorable, and persist as long as there is sufficient moisture. This group of wet meadow annuals reaches its greatest development during the late cold season and early hot season. It is such plants as these that make the seasonal succession so conspicuous. They are for the most part small plants, and contribute little toward the development of the permanent flora : *Juncellus pygmaeus* Clarke, *Scirpus michelianus* L,. *Potentilla supina* L., *Gnaphalium indicum* L., *Grangea maderaspatana* Poir., *Rumex dentatus* L., *Ranunculus sceleratus*, *Polygonum plebejum* Br., *Alternanthera sessilis* Br., *Bergia ammannioides* Robx., *Riccia sanguinea*, *Hydrolea zeylanica* Vahl., and *Glossostigma spathulatum* Arn.

Dry meadow stage. The wet meadow merges gradually into what may be called dry meadow (Fig. 11), a very extensive and uniform association dominated by perennial grasses. Under natural conditions it probably would be but an inconspicuous incident in the topographic succession, but due to the retrogressive influence of the very intense human factors, it has become for the time being the climatic climax over most of the area. This stage is connected with the wet meadow by *Cynodon dactylon* and *Eragrostis tenella*. The latter is a short-lived annual that flourishes everywhere during the rainy season, and almost completely disappears by the middle of winter.

The typical dry meadow (Fig. 11) is dominated by two perennial grasses, *Andropogon intermedius* Br., and *Elusine aegyptica* Desf. Both are able to produce a luxurient grass cover, but under severe grazing they assume a dense compact tufted habit; both propagate freely by runners. Under excessive grazing the *Andropogon* is the more persistent. In slight depressions and in the shade of trees, where growth conditions are a little less severe, three perennial Leguminosae, *Desmodium triflorum* DC., *Indigofera enneaphylla* L., and *Alysicarpus monilifer* DC. are very charateristic components of the dry meadow. They too have the tufted prostrate habit of growth. All are excellent pasture plants, and owe much of their value to their persistence under grazing and drought.

During the rainy season there is a conspicuous development of *Eragrostis tenella*, and of two annual Leguminosae, *Cassia obtusifolia* L. and *Crotalaria medicaginea* Lamk. The last two are often so abundant as to give character to the dry meadow vegetation, but they die at the beginning of the cold season, and little trace of them remains in the hot season.

Overgrazing and the intense aridity of the hot season greatly reduce the luxurience of the grasses of the dry meadow (Fig. 11), and another important constituent then becomes prominent. This is a series of small xerophytic and very persistent perennials that are able to survive both the grazing and aridity because of the development of effective perennating organs. All have deep tap roots with a perennial crown of stem, and most of them have a well developed rosette habit of growth. As the cold season advances and gradually merges into the hot season, the older and larger leaves fall, the more delicate stems are grazed off or die, and the aerial parts become reduced to a small compact crown of very resistent vegetation. In this condition they are able to bloom and produce seed abundantly. Some of the more common of these plants are:—*Convolvulus pluricaulis* Chois., *Lepidagathis trinervis* Nees, *Justicia simplex* D. Don, *Eu-*

phorbia thymifolia Burm., *Boerhaavia repens* L., *Vernonia cinerea* Less., *Corchorus antichorus* Roeusch., *Launea asplenifolia* Hook, and *Heliotropium strigosum* Willd. Equally persistent and xerophytic are two undershrubs, *Calotropis procera* Br. and *Tephrosia purpurea* Pers., and they show a similar reaction to the extreme aridity of the hot season.

It must be emphasized that the entire area is subjected to merciless grazing. Where overgrazing progresses too far, the dry meadow grasses are nearly or quite exterminated (Fig. 14), and a comparatively worthless grass, *Aristida adscenscionis* L. becomes dominant. It grows up quickly at the beginning of the rainy season, and dies out with the increasing dryness of cold season. It is fairly good for grazing while green, but when mature the awned fruits render it worse than worthless. The appearance of this grass marks the last stage of the exploitation of the plant resources by man. When it dies the ground is left bare except for a few scattering half dead tufts of the typical dry meadow grasses, and some of the more persistent of the rosette weeds.

Thorn scrub stage. Under existing conditions by far the larger part of the uncultivated area about Allahabad is in the dry meadow stage, the modified climatic climax. There are a few scattered areas that give a clue to what the next stage in the vegetation would be if left free to develop naturally (Figs. 12—15). This stage is here called provisionally "thorn scrub", for that probably is what it most closely resembles in its present condition. Nowhere is it to to be found fully developed. To complete the picture we must patch together two quite separate types: (1) areas protected from grazing, such as military and dairy grass farms (Fig. 12), and (2) uncultivated areas that bear a scattering growth of thorny shrub and small trees (Figs. 13—15).

The grass farms owe their more advanced ecological state to protection from grazing. The vegetation is practically limited to grasses and a small number of associated annual and perennial herbs. The grass is permitted to grow undisturbed to maturity, when it is cut for hay. All the cutting is done by hand, and not only the grasses but all vegetation impartially is cut off close to the ground. Such a method of harvesting very effectually prevents the development of shrubs and trees. The characteristic grasses of these protected meadows (Fig. 12) are *Apluda varia* Hack., *Cenchrus biflorus* Roxb., *Andropogon annulatus* Forsk., *A. contortus* L., *Paspalum sanguinale* Lamk., *Anthistiria imberbis* Retz., *Iseilema laxum* Hack., and *I. wightii* Anderss. It is difficult to determine which of these grasses is the most important. *Apluda varia*, a tall coarse grass, is

perhaps the first to assume a place of prominence, and is the most xerophytic. It is closely followed in point of time and in importance by *Cenchrus* and the two *Andropogons*. The remaining species are of secondary importance. Along with the grasses of such a protected area there come in a new set of herbaceous annual and perennial dicotyledons, such as *Rhynchosia minima* DC., *Alysicarpus buplcurifolius* DC., and *Crotalaria mysorensis* Roth. At times one finds a straggling *Zizyphus jujuba* or *Z. rotundifolia* Lamk., an *Acacia arabica*, or some other woody plant, but they are not numerous.

That the grasses of the protected meadows actually are the result of protection, and not a matter of special soil or moisture relations, is indicated by the fact that they are found all over the area, wherever grazing is lessened or difficult. They flourish even on the dryest of the cliffs, in positions where cattle and goats cannot readily reach them. They already potentially occupy the area, and await only protection from excessive grazing to develop into a more advanced plant formation.

The areas of thorny shrubs and small trees, which are used to give name to the stage following the dry meadow, are remnants of a pioneer type of forest that has persisted on tracts that have remained uncultivated for considerable time (Figs. 13 and 14). In some places the growth is scattering and savannah-like, in others it is more dense (Fig. 15); but everywhere the ground is occupied by a typical dry meadow association of grasses (Fig, 13). The principal species comprising this pioneer forest are *Capparis sepiaria* L., *Acacia arabica* Willd., *A. leucophloea* Willd., *Balanites aegyptica* Delile, *Justicia adhatoda* L., *Flacourtia sepiaria* Roxb., *Jatropha gossypifolia* L., *Zizyphus jujuba* Lamk. and *Alangium lamarckii* Thw. Most of these plants are conspicuously thorny, and are thus protected from complete destruction by grazing animals. *Justicia* and *Jatropha* are the only abundant ones with no obvious protection, yet animals will not eat them even when other vegetation is scarce; the latter has been introduced from Brazil, and is now completely naturalized and competes successfully with the other plants of the formation. *Alangium* also is sparingly eaten. *Balanites* is the most successful as a pioneer in dry unpromising conditions, though the *Acacias* are not much behind it in this respect.

Some distance north and west of Allahabad *Butea frondosa* Roxb., becomes one of the most important of the thorn scrub trees; there are only straggling outliers to be found in the local area. It is not thorny, but is the ecological equivalent of the thorn scrub plants.

Wherever such woody vegetation occurs it is more or less constantly cut for fuel, and the smaller plants are pruned by grazing

animals to dense oval bushes (Fig. 13). It is only when the bushes finally spread out so wide that the animals cannot reach the center that shoots spring up into trees. The thorn scrub is destroyed only by cutting combined with cultivation; cutting alone does not destroy it, for all the species coppice freely, and most of them propagate by shoots from roots. Where cutting is restricted, the *Zizyphus jujuba* and *Acacia arabica* develop into a very fair forest (Fig. 15).

As might be expected, there are no bulbous plants, and no epiphytes in the thorn scrub. There are a few lianas, the most common being species of Asclepiadaceae, notably *Hemidesmus indicus* Br. Where there is more protection, as in planted groves and in hedges around orchards, *Cocculus villosus* DC., *Tinospora cordifolia* Miers. *Vitis trifolia* L., and a number of Cucurbitaceae are common, but they are unable to survive unrestricted grazing. The parasite, *Cuscuta reflexa* Roxb., is very common, and while occurring most frequently on *Acacia arabica* and *Zizyphus jujuba*, it is able to grow impartially on almost any available host plant.

Seasonal succession is not such a conspicuous feature of the thorn scrub, though it is well shown in the dry meadow herbaceous vegetation that extends over all such areas. Periodicity is prominent only in leaf fall and in time of blooming. Many of the species are deciduous and have their flowering period during the hot season.

There is little doubt that the meadows of the grass farms and the thorn scrub woody vegetation belong to the same general stage in topographic succession. The former are shrubless and treeless because of the thoroughgoing annual cutting, the wooded areas lack the more advanced grasses because of overgrazing. If left undisturbed, both the protected meadow grasses and the thorny shrubs and trees together would very completely occupy most or all of the area now covered by dry meadows, and would become a dense thorn forest. This actually is happening in the Fisher Forests at Etawah, 200 miles to the west of Allahabad. This is an area along the Jamna River recently placed under Government supervision for afforestation experiments. It is a series of deep ravines developed as the result of the removal of the soil-holding vegetation by overgrazing and unrestricted cutting for fuel. With only five years protection, both the grasses and the woody plants of the thorn scrub stage have developed luxuriently (Fig. 12).

Nowhere over the area about Allahabad has the vegetation been able to develop without protection beyond a poor display of the thorn scrub trees and shrubs, and most of the area is in the dry meadow stage. This stage, so conspicuous under existing conditions, probably would be but a short stage following the wet meadow, or it might even not occur as a distinct stage at all, if the vegetation

could develop naturally. Such a flora now represents the climatic climax as degraded and modified by man. It is the resultant of the struggle between the vegetation on the one hand developing toward some type of climatic climax forest, and the retrogressive influence of the intense human factors on the other hand, continually interfering with and destroying it. This balance between man and the natural vegetation is very delicate, and may perhaps help to explain many of the very serious human problems of the area. After a series of favourable years, the slightly increased vegetation allows a corresponding increase in the human and animal population, and results in increased demands on the plant resources. Then subsequent bad years leave the men and animals with insufficient food, and if many do not die as the direct result of famine, they are left so weakened as to become easy prey to pestilence, and are again reduced in numbers. In other words, under present conditions, the human and animal population is about as large as the area can support. Improved methods of agriculture, and intelligent protection and conservation of the plant resources appear to the only solution of the problem.

Pioneer monsoon deciduous forest stage. If left to itself, it is very probable that the thorn scrub would in turn be replaced by some form of higher and more mesophytic forest. SCHIMPER concludes (10) that if the annual rainfall is below 90 cm., "xerophilous scrub", especially "thorn forest" and "thorn bush," prevails; with 90—150 cm. there is a struggle between "xerophilous woodland" and grassland, with the former prevailing when there are greater heat and longer rainless periods during the vegetative season. With 180 cm. or more rainfall, a high forest is produced. BRANDIS (1) says that "really thriving forests are only found where the fall exceeds 40 inches, and a rich luxurient vegetation is limited to those belts which have a much higher rainfall."

The highest type of vegetation about Allahabad, the scrubby xerophytic shrubs and trees, would, I think, correspond roughly to Schimper's "thorn scrub." Doubtless in most regions treated by Schimper, the vegetation described as climax actually is climatic climax. He was recording situations as they actually are; some of them at least are not necessarily climatic climaxes but modified claimaxes due to retrogressive influences. To class the thorn scrub of the Upper Gangetic Plain as the true climatic climax is a mistake. On Schimper's classification, the rainfall in the area about Allahabad should produce a forest somewhere between "xerophilous scrub" and "xerophilous woodland". It is difficult to determine exactly what these terms mean. Probably each writer must provisionally fix his own limits to them. Certainly

the Allahabad thorn scrub is not truly xerophilous. According to Brandis the area ought to be able to support a "really successful forest". In adjacent hilly regions, especially to the south, where there is a much smaller amount of land suitable for cultivation, and the population consequently is much less, a successful forest occurs (Fig. 16). It appears as if forests and density of population may be definitely correlated with each other in India.

We must assume then that if the human factors were lessened or eliminated, the area would more or less rapidly pass into the complete thorn scrub stage, or even into a true thorn forest. In the protection of the grasses, shrubs, and trees of this forest, a more mesophytic type of forest would develop. Some of the thorn scrub trees, as *Zizpyhus jujuba*, *Acacia arabica*, and *Alangium lamarckii*, would develop to much larger dimensions (Fig. 15). *Butea frondosa* would become abundant. Such a forest is pioneer to the climatic climax in the mountainous region to the south. Other trees, as *Dalbergia sissoo* Roxb, and *Holoptelea integrifolia* Planch, at present exclusively cultivated would quite readily become self-perpetuating components of such a forest. Finally, there would be the slower influx of truly climax trees from neighboring forested areas.

The development of such a forest might result in some increase of rainfall, making conditions still more favorable for the development of a high forest. BRANDIS records (2) an instance of slight increase of rainfall following thorough-going protection of a large forest tract in Central India. Certainly a dense intermediate forest, with its accompanying herbaceous and shrubby floor vegetation, would greatly conserve rainfall by preventing rapid run-off of the monsoon rains, and by increasing the relative humidity during the hot season.

Climatic climax monsoon deciduous forest stage. Probably the dominant constituents of the ultimate climatic climax forest would be immigrants from neighboring forested areas to the north and south. We should expect to find *Terminalia tomentosa* Bedd, and *Tectona grandis* L., dominant. Almost certainly species of *Sterculia*, *Bombax malabaricum* DC., *Anogeissus latifolia* Wall, *Stephegyne parvifolia* Korth., *Buchanania latifolia* Roxb., *Eugenia jambolana* Lamk., and other fine trees, and *Dendrocalamus strictus* Nees would invade the area from the forests both to the north and to the south. *Acacia catchu* Willd., and even *Shorea robusta* Gaertn, might finally be represented. With such immigrants, and in the protection of their shade, a new herbaceous and shrubby vegetation, at present unknown in the area, would spring up. Perhaps several species now found only in favored places in protected planted groves would become components of this undergrowth,

Such a climax forest as has been sketched above is purely hypothetical for the area, but all natural conditions seem to warrant the assumption that it would develop. It would be a typical deciduous monsoon forest, decidedly tropophytic, leafless during some portion of the hot season. It would contain few bulbous herbs, few epiphytes, abundants lianas, and would have a great abundance and variety of grasses in the more open places. The fine forests at the north side of the Upper Gangetic Plain adjacent to the Himalayas, and in the more inaccessible parts of the Vindhias to the south (Fig. 16) may be taken as a picture of this hypothetical forest.

Summary

1. The area under discussion lies in a 10 mile radius about Allahabad, and is representative of a large part of the Upper Gangetic Plain.

2. The vegetation is influenced and determined as much by biotic as by climatic factors.

3. The climatic factors, rainfall, insolation, temperature, humidity, and air movements, are periodic in distribution, and produce three distinct seasons :

(*a*) Rainy season, from the middle of June to the end of September, with high rainfull, low insolation, high temperature, and high humidity.

(*b*) Cold season, from the first of October to the end of February, with low rainlall, high insolation, low temperature, and high humidity.

(*c*) Hot season, from the first of March to the middle of June, with low rainfall, high insolation, high temperature, low humidity, and large air movement.

4. The biotic factors are an agricultural population of about 530 er square mile, and associated domestic grazing animals of about 470 per square mile. Cultivation, grazing, and cutting for food and fuel have profoundly modified the original vegetation ; constantly interfere with the normal development of the vegetation ; and cause retrogression from the original climatic climax. White ants also probably exert marked influence on the vegetation.

5. The vegetation is characterized by :
 (*a*) Distinct seasonal succession, as the result of the pronounced climatic seasons.
 (*b*) A modified climatic climax degraded several stages from the true climatic climax for the area. The vegetation is now balanced against the intense human factors, at about the dry meadow or early thorn scrub stage.
 (*c*) Obscure topographic succession, due to interference by the human factors, which at times and in places are so severe as to entirely prevent succession.

6. Topographic succession presents the following stages :—
 (*a*) Aquatic stage.
 (*b*) Wet meadow stage.
 (*c*) Dry meadow stage, which occurs over most of the area, and is the modified climatic climax.
 (*d*) Thorn scrub stage, occurring in poorly developed form in many places.

7. It seems clear from the evidence that if the retrogressive influence of the biotic factors were removed, the vegetation would pass through progressively higher forest stages :—
 (*e*) Fully developed thorn scrub stage.
 (*f*) Pioneer monsoon deciduous forest stage.
 (*g*) Climatic climax monsoon deciduous forest, a forest of considerable density and luxurience.

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Explanation of Plates.

Plate XIX

Fig. 8. Permanent lake near Allahabad, formed by damming up a ravine. *Scirpus maritimus* is dominant in the attached emersed aquatic and wet meadow stages. Note the bare wet meadow shore left by the receding water. In the back-ground is a village grove of planted trees. Photographed January 30, 1920.

Fig. 9. Shallow temporary pool near Allahabad, showing the result of cultivation and grazing on early stages of succession. In the water and stranded on the wet meadow shore are the remains of a crop of *Oryza sativa*, along with *Panicum punctatum*, *Ipomaca reptans*, and *Cynodon dactylon*. Spontaneous *Acacia arabica* in the background. This view shows the flat character of the plains. November 4, 1917.

Fig. 10. Well developed wet meadow stage in the seepage area from the permanent lake in Fig. 8. In the shallow open water are submersed aquatics; in the edges of the pools is tall *Scirpus maritimus*; over the damp soil of the wet meadow stage are *Scirpus maritimus* and *Cyperus difformis*, fringed about by a dense mat of smaller *Fimbristylis diphylla*; outside this is a later stage of the wet meadow, dominated by *Cynodon dactylon*; dry meadow plants on the higher banks; and spontaneous *Acacia arabica* and planted village trees in the background. The whole area is closely grazed. January 30, 1920.

Plate XX

Fig. 11. Well drained area west of Allahabad, showing closely grazed dry meadow stage, with cultivated fields in level places. The meadow is dominated by *Andropogon intermedius* and a good representation of small perennial prostrate weeds. Spontaneous *Acacia arabica* in the background. April 20, 1918.

Fig. 12. Rank growth of thorn scrub grasses, *Apluda varia*, *Cenchrus biflorus*, *Andropogon contortus*, and *A. intermedius*, in the Fisher Forest, Etawah, as a result of five years protection from grazing. The trees are planted *Acacia arabica*. October 24, 1919.

Fig. 13. Closely grazed thorn scrub area north of Allahabad. The trees are *Acacia arabica*, the oval bushes are *Capparis sepiaria* pruned by grazing animals, and the straggling bushes are *Justicia adhatoda*. Over the ground is a poor development of the dry meadow. April 20, 1918.

Plate XXI

Fig. 14. Overgrazed thorn scrub area north of Allahabad, showing untouched *Justicia adhatoda* and pruned *Capparis sepiaria*. The soil is bare and strewn with calcium carbonate nodules (kankar). The principal rainy season herbaceous vegetation is *Aristida adscensionis*. April 13, 1919.

Fig. 15. Closely grazed thorn scrub stage near Allahabad. It is protected from cutting and the *Acacia arabica* and *Zizyphus jujuba* have developed into a fair forest. January 30, 1920. (This forest was cut off about March 1, 1920).

Fig. 16. Climatic climax monsoon deciduous forest at Ghansore, Central India. The trees are *Sterculia urens* Robx., *Dalbergia paniculata* Robx., *Anogeissus latifolia*, *Tectona grandis*, *Semecarpus anacardium* L, *Boswellia serrata* Robx., and *Hymenodictyon excelsum* Wall. The entire area is closely grazed. Such a forest as this would be expected to develop over much of the Upper Gangetic Plain following elimination of the intense human factors. January 18, 1920.

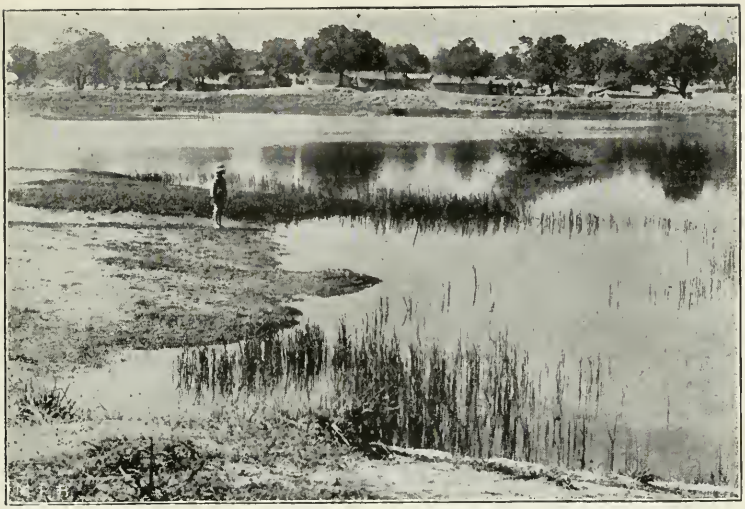


Fig. 8

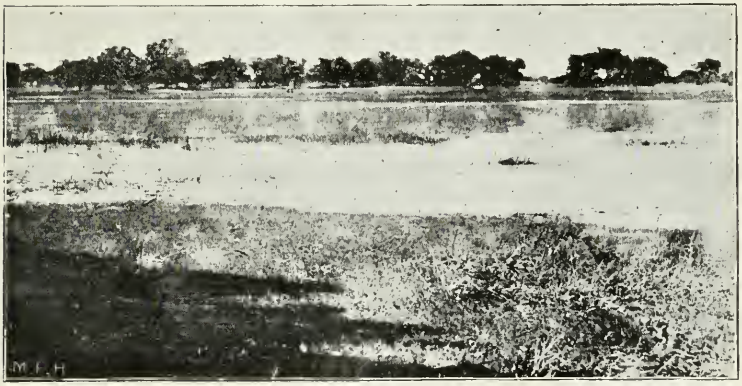


Fig. 9

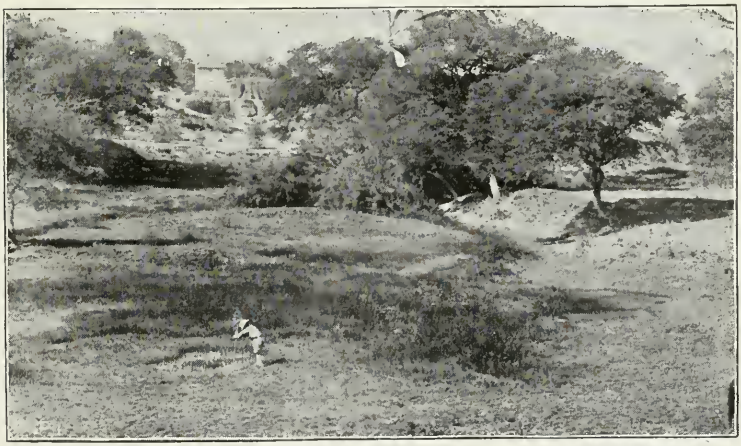


Fig. 10

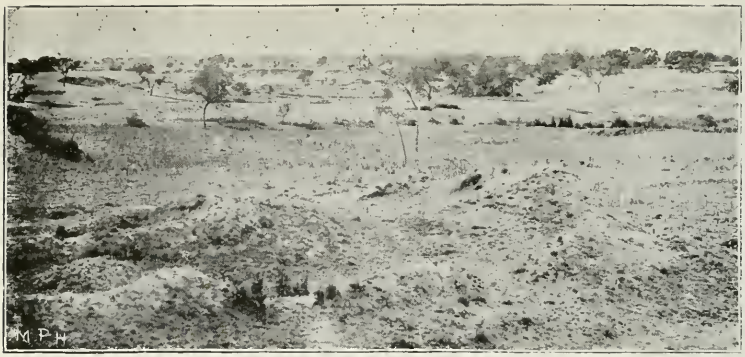


Fig. 11



Fig. 12



Fig. 13

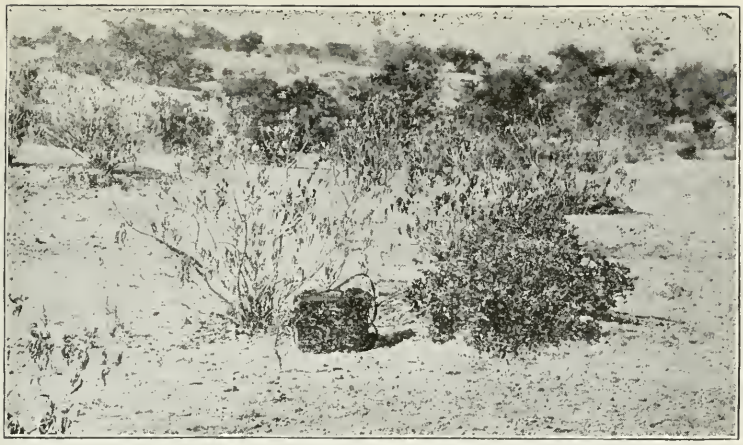


Fig. 14

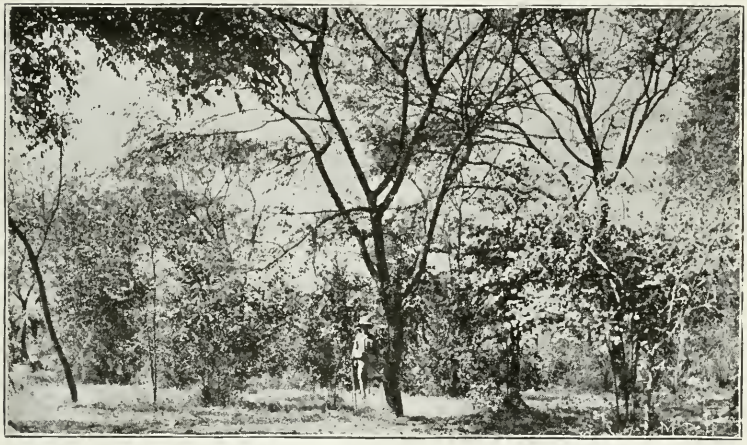


Fig. 15



Fig. 16

VARIEGATION IN CERTAIN CULTIVATED PLANTS

M. Balasubramanyam, B.A., (Hons.), *Sacred Heart College, Shembaganur.*

The interesting paper by Bateson on Variegation in certain plants, led me to examine at the instance of Professor Fyson some of the variegate species grown in Madras gardens, for the histological details of the differently coloured patches.

In *Pothos aurea*, Linden, the patches of green and yellowish-white parts are not sharply defined, partly because the loss of chlorophyll as one passes from a green to a light part is gradual, and partly because the green occurs in flecks in the light parts, and the light in flecks in the green, so that the leaf has a softly mottled appearance. On the under side the light parts are a little greener than the upper as if the chlorophyll persisted longer on the under side. The palisade on the lighter parts does not lose its characteristic structure but only its colour.

In some other plants the variegation takes the form of white patches, with very sharply defined edges because the chlorophyll is absent throughout the section. So that the patch is pure white from either side. This occurs for instance in a form of *Anthurium Sp.* where the white spots are characterised not only by the almost complete absence of chloroplasts, but also by the absence of all differentiation of tissue, the cells being nearly isodiametrie. (Pl. II, Fig. 1.)

In *Maranta vittata* variegation takes the form of narrow white streaks between and parallel to the nerves which run acutely from the mid-rib, only on the upper side. But the palisade tissue loses not only its chlorophyll but also its characteristic form and consists of rounded cells indistinguishible from the spongey parenchyma, except for being colourless. The cells of the water-storage tissue of the upper side are here smaller, and the whole section somewhat thinner. (Pl. I, Fig. 1.)

In other species are indications of the existence of a middle tissue, between the upper (palisade) and lower (spongey) tissues of the mesophyll. Thus in a common garden *Dracaena,* round ill-defined spots of slightly lighter green, about 1/16 in. diameter occur here and there in the leaf. A transverse section shows the normal mesophyll to comprise a layer of obviously elongated cells (the palisade), a second layer of much shorter cells and five or six layers of loosely

arranged cells. In the lighter coloured spots a few layers in the middle of the spongey part are without chlorophyll (Pl. II, Fig. 2). The effect of the absence of colour in this deep seated portion is to produce lighter spots with hazy, ill-defined outlines.

A variegated form of *Alocasia macrorhiza*, Schott, said to have arisen as a sport, affords a most interesting variability in the distribution of the chlorophyll—deficient tissue. This is always quite definite (as regards each layer of the leaf) without any merging as in *Pothos aurea*, or haziness as in the *Dracaena*. Sometimes a plant will give several pure white leaves which, however, soon wither, and are succeeded by more normal ones, or else the plant of course eventually dies. Sometimes one whole half of a leaf is pure creamy white, without any trace of chlorophyll, while the other half is mottled. More usually the whole leaf is mottled as shown in Plate III. The mottling is in various degrees of lightness, and different on the two sides (compare the upper and under sides of the leaf in the plate).

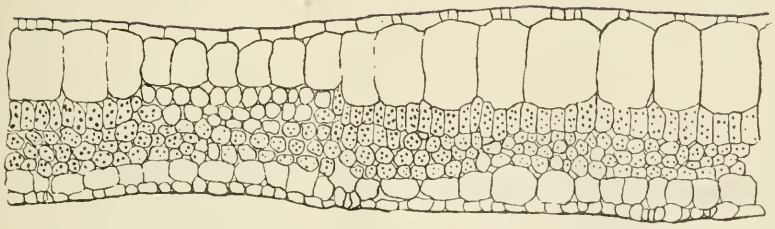
Sections through different patches show that three regions can be recognised in the mesophyll, an upper (the palisade) a middle and a lower (the spongey-parenchyma). Writing the colours of these three regions in order from the top so that W.G.W. indicates white palisade, green core and white spongey-parenchma, We find the following combinations to occur :—

G. G. G.	G. G. W.
W. G. G.	G. W. W.
W. G. W.	W. W. W.
W. W. G.	

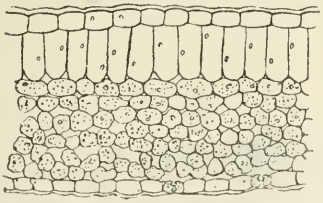
It will be seen that only one of the eight possible combinations is absent, viz., G.W.G., or white core and fully-green cortex.

Though the spongey-parenchyma is thicker than the core, the chlorophyll, is less dense, and in a leaf held up against the light, patches of W.G.W. appear to be nearly of the same tint as those of W.W.G. Again when viewed by reflected light only, patches of G.G.W. appear the same as those of G.W.W., because of the much greater intensity of the green in the palisade tissue than in the middle region, but by transmitted light they are distinguished at once except in the *Dracaena* referred to above, so far I have not found G.W.G., which would be *reverson*, in Bateson's sense of W.G.W.

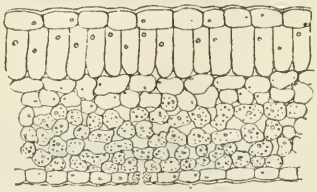
A variegated *Eranthemum Sp.* shows the third middle layer even more clearly because the cells are coloured distinctly blue. This causes the leaf to have a dark bluey green colour except round the margin and in patches where the normal green or a lighter colour occurs. Where a vascular bundle traverses the mesophyll the blue



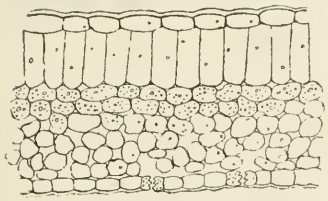
1



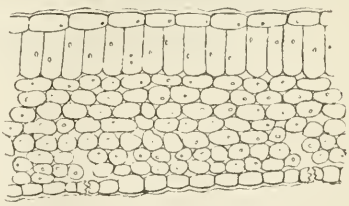
2 (WGG)



4 (WWG)

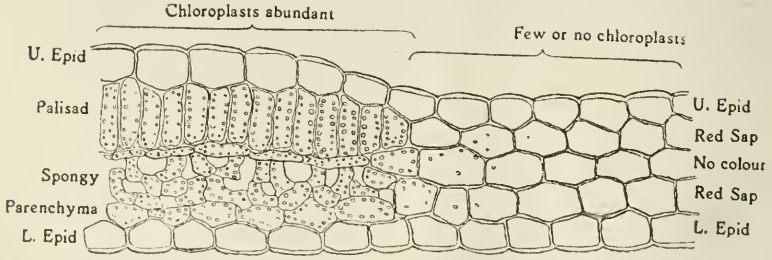


3 (WGW)

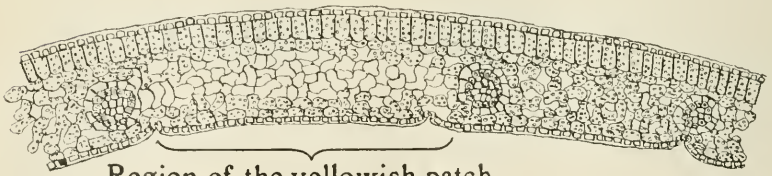


5 (WWW)

PLATE I



1

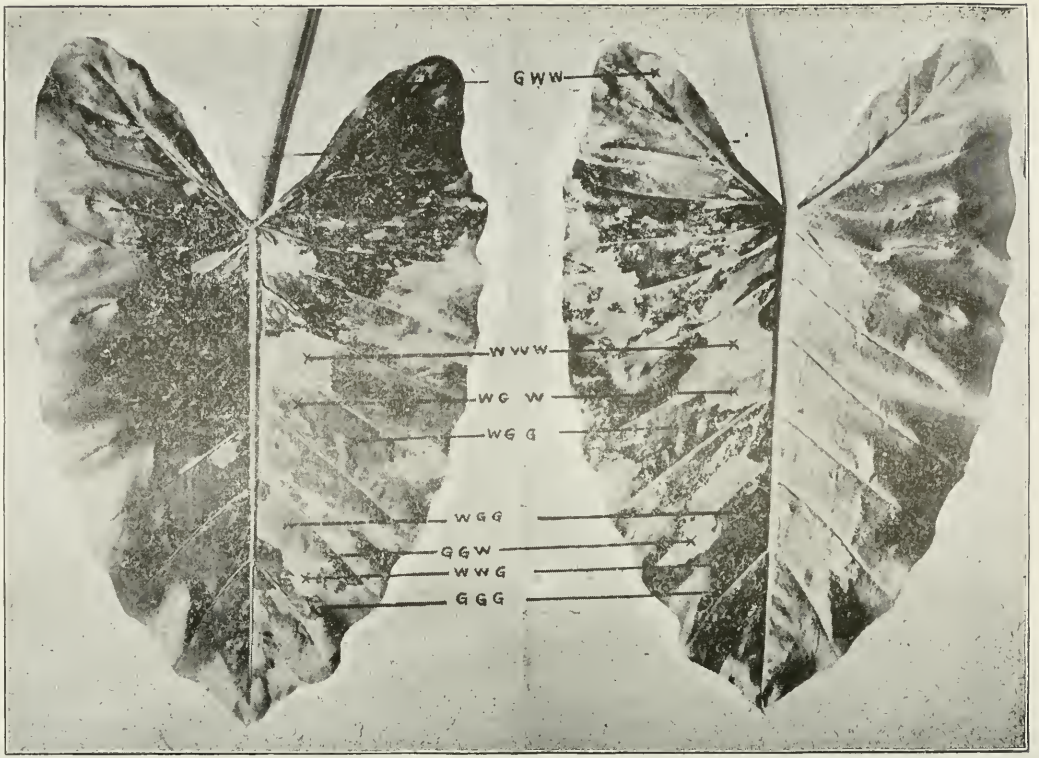


Region of the yellowish patch

2

PLATE II.

PLATE III



layers appear to expand and embrace the bundle, but to lose its distinctive blue colour.

Breynia rhamnoides a wild species common in Madras, affords another and curious type of variegation. In this the leaves, especially towards the ends of the branchlets are mostly white with dark green patches on the upper side and lighter green ones below. The upper and lower patches do not cover each other and a leaf seen against the light shows six different shades of green. The dark green patches of the upper side may be seen even with the naked eye to be definitely raised above general white surface and are due to the presence there of the paliside tissue which is entirely absent elsewhere. Lighter patches on the lower side are due to the absence of chlorophyll in the spongey parenchyma, which, however, unlike the palisade, is of normal structure throughout. In addition to the two departures from the normal structure there is again, as in the variegated *Alocasia* a middle layer which, usually green, is white in some patches. Using the same notation as with Alocasia but marking—when a tissue is absent altogether, we find the following variegations to occur :—

G. G. G.	G. G. W.	G. W. W.
—G. G.	—W. G.	—W. W.
—G. W.		

Conclusion

Variegated leaves of commonly cultivated plants in Madras show that very frequently there are in the leaf not two kinds of mesophyll-tissue as usually stated, but three. And since the chlorophyll may be present or absent independently in these, they appear to be fundamentally distinct. Though in most plants examined, the middle layer was never found to be white unless one or other of the other two layers are, in *Dracaena* the middle layer is white in circular patches while the rest is green.

This has the appearance of the green skin over the white core of Enonymus *Sp.* etc. (Bateson l.c. p. 96), but the sub-epidermal white skin, as distinct from the palisade and spongey tissues as illustrated by Bateson (l.c.) has not been met with.

Explanation of Plate II

Fig. 1. Section through part of the variegated leaf of *Maranta vittata*, showing normal green tissue on right of a white streak.

Fig. 2. Section through leaf of *Dracaena Sp.* Showing absence of chlorophasts in the middle region.

OBSERVATIONS ON THE VOLVOCACEAE OF MADRAS *

BY

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Though there have been some very valuable contributions by algologists like Fritsch (3 and 4), West (6) and (7), Wallich (5), Zeller (10), and others, on the Fresh-water Algal Flora of the Indian region, there has been practically, with the exception of some stray notes, (1, 2, and 8 page 178), no account whatever, either systematic or ecological of the Volvocaceae of India.

Fritsch (3) in his systematic account of the Algal Flora of the Tropics does not refer to the Volvocaceae at all, though records of their occurrence have not been wanting, one of them, (*Pleodorina*), having been recorded by himself (2) from Ceylon. Again West G. S. 9) has recorded some new African species of *Volvox*. He says (8, (page 182), "*Volvox africanus* is known to occur only from the plankton of Albert Nyanza." He has also recorded *Pleodorina illinoisensis* from Madras (8, page 178). He, however, expresses the opinion that the members of this family are on the whole cold water types (8, page 429). It would therefore appear that the members of the Volvocaceae are regarded by European algologists as preeminently cold water types. The primary object of this paper is to draw attention to the very common and abundant occurrence of this family in Madras, a typically semi-dry tropical place. In fact as may be seen below they attain their maximum development only during the warmer parts of the year.

Climatic Details

Madras is quite different from the other parts of India as regards its supply of rain. While all the other parts of India get their maximum supply of rain during the months June to September from the S. W. or Summer Monsoon, the Madras coast districts (from Ganjam to Negapatam) get their chief rain supply during the months October to December from the N. E. or Winter Monsoon. The S. W. Monsoon is only of minor importance on the Madras coast and moreover does not directly bring any rain to Madras. During the breaks in this monsoon on the west coast and towards

* A paper read before the Botanical Section of the Indian Science Congress Meeting at Nagpur, 1920.

the end of it, when its force gets more and more spent, we in Madras get small showers (local showers) at very frequent intervals.

The effect of these small intermittent summer showers is, falling as they do on a parched up soil, merely to wet the surface soil and to fill up the various small depressions in the ground, causing numerous rain water pools all over the place. During these Summer Monsoon months the water in these pools is constantly changing its level. Thus after a fairly good rain the depressions are filled up. During the succeeding rainless days, the level of the water goes down slowly, and in the shallower depressions the water dries up completely. In the deeper pools, however, where the water does not get completely dried up, a fresh rain sends the level up once more. And this process is repeated again and again.

During the N. E. or Winter Monsoon, the rains are heavy and generally continuous. And all the big tanks, streams, ponds, pools, and all low-lying tracts of land get filled up and often overflow. The numerous small rain-water pools that are merely filled up during the Summer Monsoon Season are during this season completely flooded and practically washed out.

The temperature during the S. W. Monsoon months though slightly lower than in May is still fairly high and the sky is generally cloudy and the weather very sultry, the month of September being the most sultry and trying part of the whole year. But with the advent of the N. E. or the Winter Monsoon, the temperature soon goes down and the weather, though the sky is often cloudy, is quite cool and pleasant.

The following table gives the details of the temperature, rainfall and cloud values of the different months of 1919 at Madras :—

1919	Average Max. Temperature for the month	Average Min Temperature for the month.	Average Mean Temperature for the month.	Highest Max. Temperature for the month.	Lowest Min. Temperature for the month	Number of rainy days in the month.	Total amount of rain for the month in inches.	Average Cloud value for the month (Overcast Sky = 100).
January ...	85°.3	72°.1	78°.7	87°.4	64°.5	1	0·37	36
February ...	87·7	71·4	79·5	93·5	68·4	*Nil.*	*Nil.*	28
March ...	88·7	72·0	80·4	94·9	66·4	2	1·96	13
April ...	93·6	78·7	86·1	98·3	73·7	*Nil.*	*Nil.*	27
May ...	99·3	81·3	90·2	108·2	76·5	2	0·03	33
June ...	98·8	80·8	89·8	105·0	70·2	12	2·49	71
July ...	94·3	78·2	86·2	102·2	73·5	12	6·16	63
August ...	96·5	79·0	87·7	101·1	74·0	8	3·12	66
September ...	91·8	76·9	84·3	99 0	73·3	10	6·78	49
October ...	89·2	76·3	82·7	96·2	73·1	16	10·80	57
November ...	86·2	74·4	80·3	90·6	70·5	14	2·83	61
December ...	83·4	72·3	77·8	86·3	67·4	13	6·24	64

Occurrence of the Volvocaceae

The members of this group occur in different kinds of situation; rain-water pools, permanent pools, ponds, ditches, water tubs, paddy-fields, streams, and tanks. They occur throughout the year but attain their greatest development and occur as dominant forms only during the summer monsoon season in the many small rain-water pools that are then formed. During the colder season, though they occur in various situations, they never reach the abundance noticeable in the rain-water pools formed during the summer season, but occur only as subordinate forms, though occasionally *Volvox* or *Pleodorina* may occur for very brief periods as dominant forms in certain waters. I shall now take up the summer monsoon rain-water pools as being the more interesting of the two.

Summer rain-water pools

After the first few summer showers, the water collected in the various rain-water pools all over the place, begins to turn green. And an examination of a drop of this green water shows countless numbers of some member or members of the Volvocaceae. The following genera have been collected by me in these pools during the summer monsoon season:—*Chlamydomonas*, *Carteria*, *Gonium*, *Pandorina*, *Eudorina*, and *Volvox*. All excepting *Volvox* were found in great abundance.

The behaviour of these organisms in the summer rain-water pools is rather interesting. As was pointed out above, the rains during this season are small in quantity and occur at frequent intervals. During the rainless days succeeding a rainy day the water level in the pool goes down gradually and when almost near the bottom a fresh rain comes in and the level of the water goes up once more; and this process is repeated again and again throughout the season.

A few days after the filling up of a pool, the level goes down somewhat and a greenish scum is noticeable on the surface which soon extends deeper and becomes greener. And an examination of a drop of this green water shows large numbers of some member or members of the Volvocaceae (mixed up of course with some diatoms, and some other plankton algae, such as *Scencdesmus*, *Coelastrum*, etc.). As the level goes down, the water gets even more green in colour. But when the pool gets filled up in the next rain, the green colour does not get thinner through dilution but disappears totally. After the level goes down somewhat again as before, a thin green scum is formed and as the level goes down still more the colour deepens and the organisms are seen in large numbers as before. And this interesting process is repeated again and again.

There is yet another interesting behaviour on the part of these organisms. Very early in the mornings the organisms are not so noticeable, but a little later they swim actively all over the water. Towards the middle of the day they recede below again, and towards the evening they float up and form a sort of green mucilaginous film on the surface. In this condition they are generally more quiescent and often are dividing and forming daughter cells or colonies.

Beach Pools

Sand is removed from the Madras Beach for building purposes and fairly deep hollows are formed in the sands very near the shore. During the monsoon seasons a large quantity of rain-water flows down from the Marina Road (which runs parallel to the seashore and is at a higher level than the sandy beach), and fills up these depressions in the sand. Again during the rainy weather the waves are rougher and some sea water also flows over the sandy shore into these pools. These pools, sometime after their formation, both during the summer monsoon and winter monsoon seasons, are soon peopled by large numbers of some member or members of the Volvocaceae. The most interesting feature of these pools is that the wet sand all round the edge of the pool to a distance of a foot or two is quite green. On lightly scraping the surface with a knife I found that the sand was green only near the surface. Microscopical examination of the wet sand revealed a large number of *Chlamydomonas* and other members of the Volvocaceae swimming actively in the thin film of water surrounding the sand particles. Some of this green sand was collected by scraping the surface lightly and shaken with some water. The water became quite green leaving the sand in its normal colour. A drop of this green water examined under the microscope showed the organisms actively swimming about. I found this same preference for the wet banks in other similar situations also. The organisms prefer this situation probably because of better conditions of aeration. In another instance I found that a depression in the beach sands was merely wet at the bottom without any water in it. The surface of this depression was covered by a very thin layer of dry sand which was blown over by the wind. On removing this dry sand lightly with a knife I found the lower layer of sand wet and greenish. I also found that the greenness was confined only to a thin layer at the top and lower down the green colour was absent. I shook some of this green sand with water and found that its greenness was due to a large number of Chlamydomonadine cells which had lost their cilia and were quiescent.

This invasion by the free swimming *Chlamydomonas* of a wet sub-aerial region, in the first place, and, in the second place, its losing its cilia under a comparatively drier condition, suggests a probable method by which some of the sub-aerial unicellular Green Algae might have evolved from some free swimming Chlamydomonadine type.

Genera collected

The following genera have been collected by me at Madras :— *Chlamydomonas*, *Carteria*; *Gonium*, *Pandorina*, *Eudorina*, *Pleodorina* and *Volvox*. The most common ones were *Chlamydomonas* and *Carteria* among the unicellular forms, and *Pandorina* and next *Eudorina* among the coenobial forms. *Gonium* was a rarer form. *Pleodorina* was still rarer. But the rarest was *Volvox*.

These forms I must however point out were always associated with a sprinkling, large or small, of other plankton forms of Algae, and Flagllate (such as *Euglena*, etc.).

One feature which was particularly noticeable in the summer rain-water pools was the complete absence of *Spirogyra* and the other filamentous Green Algae, and the extreme scarcity of the Blue Green Algae.

Enemies of the Volvocaceae

The bottom of the pools very often showed large numbers of amoebae; and these injested a large number of the unicelluler algae during the times when the latter settled down at the bottom. I came across many amoebae, with *Chlamydomonas* in their bodies and I saw some actually in the act of injesting them.

In another pool I found *Pandorina* and *Eudorina* swimming with one or two, sometimes even four or five, small round colourless Protozoons attached to their mucilaginous envelope. On further examination I found that these Protozoons gradually made their way inside and swallowed some of the cells of the colony. Later on they escaped from the colony leaving a big rent in the mucilaginous envelope. Many specimens of *Pandorina* and *Eudorina* were found by me with a big rent in their body and a few of their cells missing.

Another enemy which plays havoc with these forms is a kind of Rotifer. This was found in very large numbers in a tub containing *Pleodorina* and *Eudorina* devouring them in large numbers.

I came across a *Chironomus* larva ("Blood-worm"), devouring large quantities of *Pandorina*. This larva has the habit of constructing out of the materials of its environment such as silt, etc., a kind of case for itself by fastening with the help of a silk-like secretion of its salivary glands. I kept some quantity of live *Pandorina* in a dish. The next morning I found a large number of green cases attached to the

bottom of the dish ; and inside each case was a *Chironomus* larva which escaped out on being disturbed with a needle. An examination of a green case showed that it was made up of large numbers of *Pandorina* colonies. The larva on being examined under the microscope showed that it had been feeding on these *Pandorina* colonies ; for its alimentary canal was full of them.

Another curious phenomenon noticed by me was a tiny unicellular Blue Green Alga attached to the body of a *Chlamydomonas*. This Blue Green Alga was evidently getting a free ride at the expense of the *Chlamydomonas* and benefiting by the advantages of the locomotion, viz., better aeration and better food supply. Often there was more than one rider on a single *Chlamydomonas*, sometimes as many as five or more. I occasionally came across a few cases where the riders were too many in number for the poor *Chlamydomonas* to carry, which was therefore unable to move at all.

Summary

The following members of the Volvocaceae have been collected from Madras : --*Chlamydomonas*, *Carteria*, *Gonium*, *Pandorina*, *Eudorina Pleodorina* and *Volvox*. The last two are generally very rare forms.

Though these forms may occur in various parts of the year and in various situations, they attain their greatest luxuriance only in the many small rain-water pools formed by the showers of the Summer Monsoon season which at Madras are generally light and irregular, though frequent.

The organisms seem to like light of moderate intensity. They come up sometime after sun-rise and if, in the middle of the day, the sun-light is too strong, recede below and come up again towards the latter part of the day and form a thick green film on the surface. In this condition the organisms are generally very inactive. They sink down again during the night. If the weather is cloudy they do not sink down in the middle of the day, nor do they float up, towards the evening to form a film, but are active throughout the day.

In certain rain-water pools formed in the Madras Beach, these organisms are often found in large numbers on the wet sand around the pool giving it a green colour. This situation is sought by them probably for securing better aeration. In one of these pools where the water had disappeared the wet sand was greenish, and its greenness was due to many quiescent Chlamydomonadine cells without cilia, This invasion of a sub-aerial region by a free swimming aquatic form suggests how some sub-aerial unicellular Green Algae might have originally evolved from some free swimming Chlamydomonadine type.

Certain very small animals were observed to live on some members of this group. The most interesting among them was a *Chironomus* larva (a kind of " blood-worm"), which fed very largely on *Pandorina* colonies and at the same time made a case to live in out of these colonies by fastening a large number of them together by means of a silk-like secretion from its salivary glands.

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NOTE ON CURVATURE OF CUT STEMS OF BRYOPHYLLUM CALYCINUM

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Loeb in 1917 published (1) the results of a series of experiments on curvature induced in cut stems of *Bryophyllum calycinum*, suspended in moist air by threads, one at each end. He found, and published figures in support, that curvature, apparently due to gravity took place, whether leaves were left attached to the plant or not; but much more strongly so, when a leaf near the apical end was left, than when all but a basal leaf were removed. He also found that roots were formed adventitiously, on that region only where the curvature was a maximum, and that root-formation was strongest, when an apical rather than a basal leaf was left. From this, he drew the conclusion, that special root-forming and curvature-producing substances (hormones) are manufactured in the leaf, and passed downwards, but not upwards, along with the products of assimilation.

The experiments described here, were made to test these facts and deductions on plants growing in Madras. Healthy stems of *Bryophyllum calycinum* were used and straight pieces 6 to 8 inches long were cut, and in every case the apical bud and the first visible internode, were removed to prevent continued growth, as was done by Loeb.

All the leaves were removed except one or both apical leaves or, one or both basal leaves, and the pieces suspended over water in a glass chamber. No particular difference was observed, which could be correlated with the presence of one or both leaves, whether at the base or apex: But those with one or both apical leaves curved more than those with basal. (Plate I, figs 1, 2 and 3) Loeb in explaining this as due to the formation of geotropic hormones in the leaf and their passage always down the stem, appears to have overlooked the possibility of the curvature being induced by weight, for no attempt apparently, was made to eliminate this. We found however, that if a third thread was used to support the piece at its centre of gravity or if the pieces were laid on a flat board (fig. 11) no curvature took place. (Compare in Plate I, figs. 8, 9, 10 with 5, 6, 7.)

In order to support the piece without introducing other factors, we attached to the piece near its centre of gravity a fine thread, which after passing over a pulley, supported a pan, in which weights were

placed to counter-balance, the weight of the piece. Plate II, fig. 27 shows how this was done, and it will be seen that no appreciable curvature took place. In the course of the experiment a lessening of the weight, by loss of evaporated water caused the terminal threads to slacken ; but at the beginning of the experiment, the weight was evenly distributed and the lack of curvature cannot therefore, be due to any pull upwards, at the centre of gravity.

Since the region of curvature is in the weak still unlignified internodes near the apex (vide figs. 1, 2 and 3) it is clear that the bending moment at the point of curvature due to the comparatively heavy, succulent leaves, will be much greater when these are at the apical end, than if they are at the basal (compare figs. 1 and 2 with 3).

In another series of experiments living stems of *Coleus* still attached to the roots, were laid horizontally, the growing point and the first visible internode, being removed as before. Three pairs of plants were used, and in one of each pair, a pair of apical leaves was left, while in the other one or more near the base. Plate II, fig. 19-26 show the resulting curvature after 24 hours. It will be seen that no definite relationship, can be established between the amount of curvature and the existence or position of leaves Compare Nos. 19 with 20, 23 with 24, 21 and 22 with 25 and 26.

B. The root-forming ' hormones'—Our experiments failed likewise to support Loeb's theory, that root-formation is due to hormones produced in the leaf. Roots were formed freely on the lower side and especially at the region of curvature (figs. 1 and 4) of stems kept damp ; but in no apparent relation with the existence or position of leaves. The presence of water, we found to be a much more important factor.

Pieces of stem were placed vertically, in the normal or the reversed position, and one end kept damp, by tying a wet rag round it. In every case roots appeared, whether at the upper or lower end, whether at the apical or the basal. This is exactly in conformity with Klebs results (7).

This occurred also with both isolated and attached leaves of *Bryophyllum*. Roots appeared always in a day or two, at the parts kept wet. Loeb's results (4) of hanging leaves in different positions. which led him to postulate a flow of root-forming substances towards the base of a leaf appear therefore, to have been accidental. In our experiments, leaves were hung in a vertical plane.

(1) by the petiole
(2) by a hole in the apical end
(3) by a hole at one side and
(4) horizontally by threads through two holes in the lamina.

In every case provided the atmosphere was kept saturated, roots appeared with apparently equal facility at any notch.

C. Regeneration. According to Loeb, the growth of roots and shoots, at the marginal notches of a leaf is ordinarily inhibited, by suction of the stem and especially of the growing axillary buds. To verify this :—

(1) A piece of the stem of *Bryophyllum* had one leaf at the basal portion alone left, and it was left in a moist chamber supported in the horizontal position on a board. On the 7th day (Plate I, fig. 11) roots had grown out from the notches of the single leaf, and the opposite bud showed signs of growth. On the 14th day, the bud opposite the basal leaf had fully grown out and several shoots also had appeared from the notches of the basal leaf. Roots had also appeared from the under-side of the basal node.

Now, if really the opposite bud inhibited the growth in the notches of the basal leaf, one would expect that as the opposite bud began to grow, the roots that had grown from the notches of the basal leaf would not have developed any further. On the contrary, they continued to grow, and shoots also appeared from the notches. In short, the growth in the notches of the leaf, progressed side by side with the growth of the opposite bud. Hence, apparently no inhibition had taken place.

(2) Two pieces of the stem of *Bryophyllum*, containing each a single node with only one leaf attached were suspended so that part of the lower leaf was sub-merged in water. After 10 days, it was found that the submerged notches of the lower leaf, in each case, had developed roots, while the opposite bud also was developing. (Plate I, figs. 12 and 13).

(3) A piece of the stem of *Bryophyllum* containing a single node with two leaves attached was arranged so that one of the leaves had a part submerged in water. On the 6th day roots were found to have grown out from the notches of the submerged lower leaf. On the 9th day the bud in the axil of the submerged leaf, as well as the bud in the axil of the opposite leaf had developed. The upper leaf withered and finally fell off, and is therefore not seen in the photograph (Plate I, fig. 18). A root had also grown from the piece of stem.

In this case again, if Loeb's inhibition theory were correct, one would expect that since each of the axillary buds inhibited the development of the opposite leaf, none of the two leaves should have grown any roots in their notches. As a matter of fact, the lower submerged leaf produced roots in its notches and its opposite bud also developed, as also the other axillary bud.

From this we may conclude that neither the stem itself, nor the opposite bud, nor the axillary bud, exert any absolute inhibition, on the development of the marginal notches, and probably affect it very little.

D. Regeneration in leaves still attached to the living plant.— Several normal, erect, healthy plants of *Bryophyllum* were found in which roots and shoots had arisen from the notches of several leaves in contact with the parent plant. It should be mentioned that the preceding week had been a very rainy one. Most of the leaves which had grown shoots at their notches were found to be of a slightly paler green colour, but there were also several green leaves among the number. In none of these stems had the terminal buds been injured or destroyed and they were growing quite well. In the case of one plant where the terminal bud, had been accidentally destroyed, the notches in the leaves had not grown out, but the axillary bud lower down, was starting to grow. The stems of all these plants were quite erect and to all appearance normal. There was no indication of their roots having been injured or of any other pathological condition as suggested by Loeb in his objection (5) to Miss Lucy Braun's very similar observation.

Loeb, indeed contended (1) that "when these leaves are attached to the stem of the whole plant, in the natural condition, they never produce roots and shoots in their notches." The chief factors which he mentions, as tending to prevent the formation of roots and shoots on the leaves when in the natural condition, are (1) the growth of buds on the main stem and (2) root-pressure. His explanation is that the formative materials which are required for active growth, are constantly flowing to the terminal bud from all the other parts of the plant and hence the notches in the leaves have no chance of growing. This explanation does not, however, apply to the instances cited above, as in all those cases, the terminal buds on the main erect stems were quite healthy and active.

Turning now, to the second factor that Loeb mentions, he says that the presence or growth of roots on the main stem inhibits the growth of notches in the leaves because of root-pressure.

It is difficult to conceive how root-pressure can inhibit growth in the notches of the leaf, and Loeb does not explain how it does. In the concluding passages of his paper (1), he says that attempts to induce growth in the notches of the leaves proved futile. He says "the writer left several leaves of the plant submerged in water for months without any results", and therefore concludes that root-pressure is the inhibiting factor.

With a view to find out, whether this was really the case, three

leaves of a plant growing in the ground, which had not grown any roots or shoots in the notches of its leaves, were selected and they were left dipping in water contained in a basin, on the 2nd of December, 1919. Three days later on the 5th of December, roots were found to have grown out from the submerged notches of the leaf, to a length of nearly half an inch. On the 8th December, small shoots also had grown out from the notches.

These observations deny the inhibiting influence of root-pressure and suggest the moist external conditions as accounting for the growth. This is quite in consonance with the fact that the notches in the leaves of the plants had grown out just after a week of heavy rain, although root-pressure must then, presumably, have been considerable, because of the very little transpiration that was possible.

The following experiment appears to be conclusive. A pot plant of *Bryophyllum* was taken and the stem of the plant was cut off leaving only the last basal node with the two leaves attached. The cut end of the stem was sealed firmly with canada balsam, to prevent water from being forced out and resulting in a diminution of root-pressure. The axillary buds of both the leaves, were destroyed. One of the two leaves was left dipping in a basin of water so that part of it was submerged. On the 6th day, roots were found to have grown out in clusters from the notches of the submerged portion of the leaf. Later on small shoots also appeared. Here if, as seems probable, there was considerable root-pressure, the formation of roots and shoots from the leaf-notches was not in any way inhibited.

Summary

Experiments were made to determine whether special root-forming and curvature-producing substances could be recognised as being formed in the leaves, as assumed by Loeb on the results of his observations on *Bryophyllum calycinum*. They were in the first instance a repetition of his experiments, but with certain modifications to eliminate the effects of weight. We find no evidence in support of the theory of special curvature-producing hormones, nor of root-forming substances. On the other hand our observations confirm those of Klebs on the effect of an excess of water on adventitious root-formation.

A further series of experiments on the effect of the growth of an axillary bud on the development of the marginal leaf-notches, failed to confirm Loeb's results. All differences in the rate and amount of growth of roots and shoots from the margins of the leaf, can in our

opinion be sufficiently explained by the suction naturally produced, by a developing organ, on the water and sap locally available, without the assumption of any special inhibitory action. Development of the marginal notches we found to be induced readily by an excess of water, which appeared to be the sole determining cause. Moreover, our observations entirely negatived Loeb's supposition of an inhibitory effect of root-pressure on this development.

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Description of Plates

Plate I

Figs. 1—7. Pieces of Bryophyllum calycinum hung by two threads.

Figs. 8—10. Pieces hung by three threads, the middle thread attached at about the centre of gravity. The positions of the threads, which being invisible against the white background, has been indicated in the original photographs by hand. Apical or basal leaves left as shown. All others removed and terminal bud and first visible internode destroyed.

Fig. 11. Piece of Bryophyllum left on a board. One leaf was left, the others removed as above. The opposite axillary bud has developed but this has not inhibited the growth at the leaf notches. Note no bending.

PLATE I

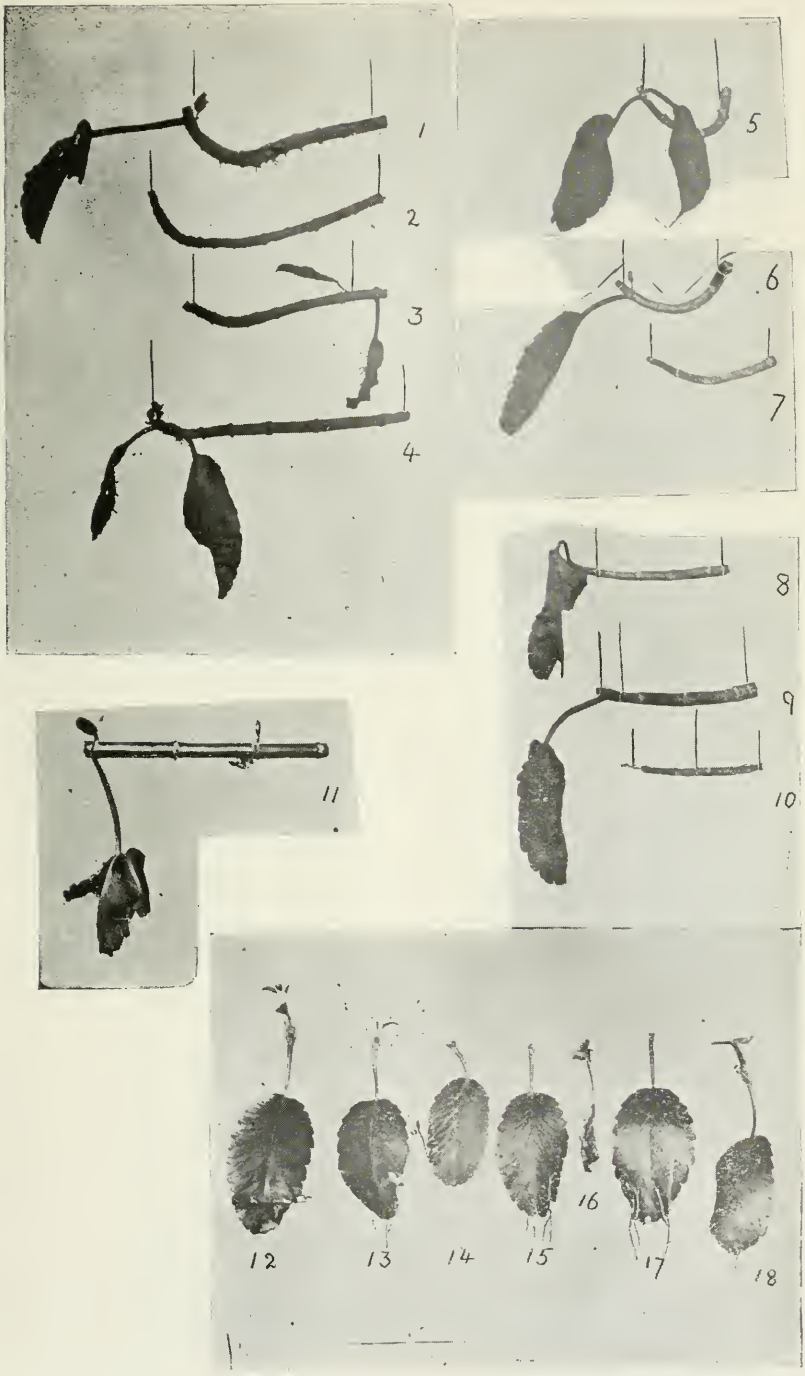
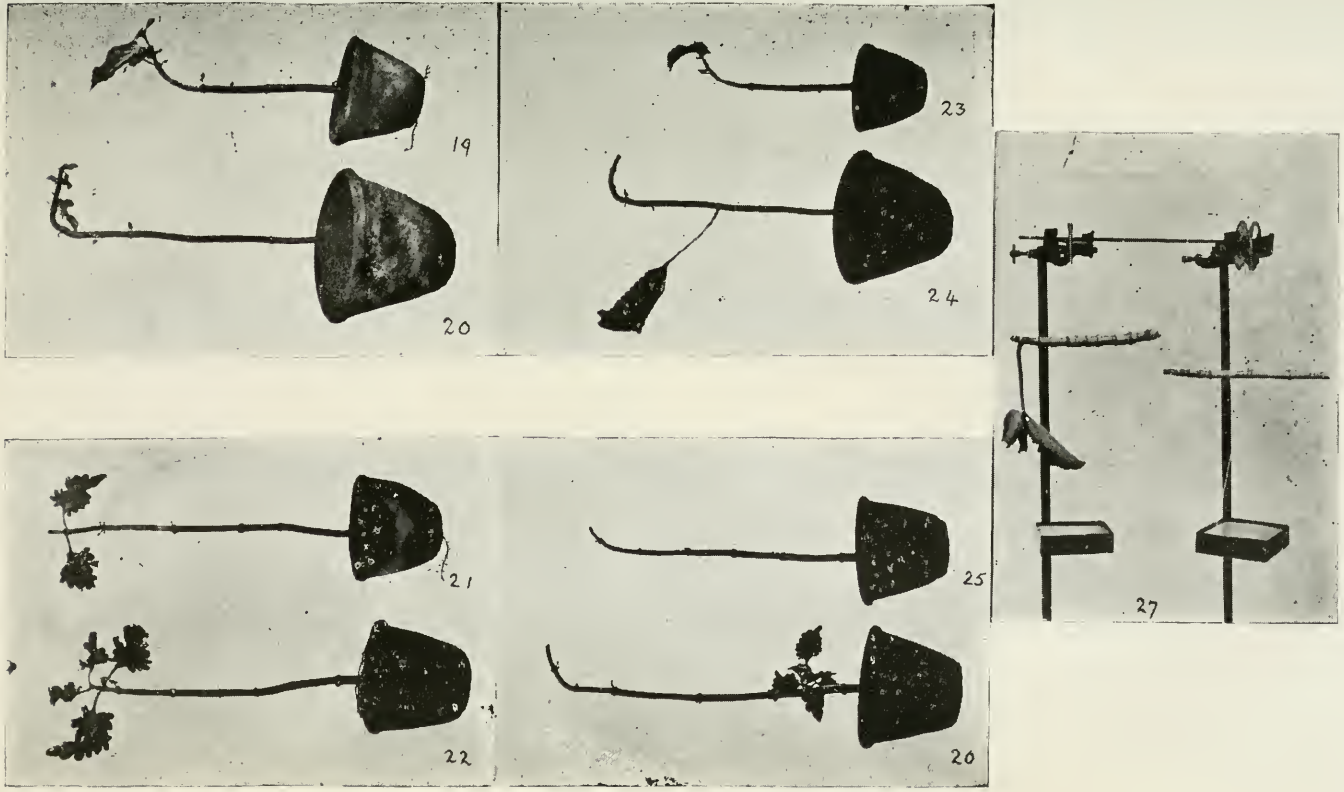


PLATE II



Figs. 12—15 & 17, 18. Leaves of Bryophyllum variously isolated and hung with lower part in water showing development at the marginal notches from the submerged parts.

Nos. 12 & 13. The opposite axillary bud allowed to develope.

No. 14. The opposite axillary bud removed.

No. 15. The stem cut in half longitudinally.

No. 16. Leaf hung dry, no part submerged.

No. 17. No part of stem left attached to leaf.

No. 18. Opposite leaf left attached (but subsequently fell off).

PLATE II

Figs. 19—24. Rooted plants of Coleus bicolor placed horizontally. Photographed after a few days. One or both leaves near the apex or near the base left attached, all others and the terminal bud removed.

Nos. 25 & 26. No leaves left attached. A lateral bud has developed near the base of No. 26.

Fig. 27. The method of hanging pieces by three threads, adopted for Nos. 8, 9 & 10.

CONTRIBUTIONS TOWARDS A FLORA OF BALUCHISTAN

From materials supplied by Col. J. E. B. Hotson, I.A.R.O.

BY

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(*Continued from last issue*)

Urticaceae.

Morus *L.*

Morus alba *L. Sp. Pl. 986.*—Loc.: Garmkan, 1 mile NE of Panjgur, about 3,125 ft. (no. M 168); Shahdadzai, 72 miles S. of Kalat, 5,100 ft. (no. 148).—Fl. in March 1918.

Vern. Name: Tut (Bal. and Br.).

Ficus *L.*

Ficus bengalensis *L. Hort. Cliff. 471, n. 4.*—Loc.: Las Bela, about 700 ft. (no. 399A); Pasni, sea level (no. M47).—Fr. in Oct. 1917.

Vern. Name: Kark (Bal.).

Ficus palmata *Forsk. Fl. Aeg. Arab. 179.*—Loc.: Jebri, 147 miles SSW of Kalat, 3,850 ft. (no. 224); Gajar, 165 miles SSW of Kalat, 3,450 ft. (no. 224A).

Vern. Names: Hanjir, Anjir (Br. and Bal.).

Ficus carica *L. Sp. Pl. 1059.* var. **rupestris** *Hausskn.*—Loc.: Nag (W. Kolwa), about 83 miles E. by N. of Turbat, about 2,300 ft. (no. M237).—Fl. in April 1918.

Vern. Name: Anjir, Hanjir (Bal. etc.).

Forskohlea *L.*

Forskohlea tenacissima *L. Mant. 72.*—Loc.: Sor, about 74 miles S. of Panjgur, 2,300, ft.; Zidi, 15 miles ESE of Khozdar, about 3,600 ft. (no. 256A.); Pirandar, 205 miles SSW of Kalat, about 1,900 ft. (no. 256); Sor (Kil Kaur) about 74 miles S. of Panjgur, 2,300 ft. (no. M215).—Fr. in April 1918.

Vern. Name: Liguri, (Br.).

Salicaceae.

Salix *L.*

Salix acmophylla *Boiss. Diagn. VII, 98.*—Loc.: Sitani, 59 miles S. of Kalat, 5,300 ft. (no. 118).

Vern. Name: Ghot (Br.), Bhed (Bal.).

Salix angustifolia *Willd. Sp. Pl. IV, 699.*—Loc.: Kuchkan (Kharan) about 30 miles NNW of Mangeli (Jhalarwan) about 3,300 ft. (no. M229).

Vern. Name: Bhed (Bal.), Ghet (Br.).

POPULUS *L.*

Populus euphratica *Oliv. Voy. III, 449, t. 45, 46.*—Loc.: Shahdadzai, 72 miles S. of Kalat, 5,300 ft. (no. 144); below Bhani, 131 miles SSW of Kalat, almost 4,000 ft. (no. 206); Awwaran, 26° 24′ N, 65° 12′ E, about 1,750 ft. (no. M280).

Vern. Name: Patk (Bal. and Br.), Bahan (Br. Bal., Sind, etc.).

Populus alba *L. Sp. Pl. 1034.*—Loc.: Shahdadzai, 72 miles S. of Kalat, 5,100 ft. (no. 146).

Vern. Name: Ispidar (Br.).

Orchidaceae.

Epipactis consimilis *Wall. Cat. no. 7403.*—Loc.: Near Chambar (no. M 261B); Anjiri Kaur, S. of Chambar (Kolwa), about 2,150 ft. (no. M261).—Fl. and Fr. April 1918.

Iridaceae.

GLADIOLUS *L.*

Gladiolus segetum *Ker.-Gawl. in Bot. Mag. t. 719.*—Loc.: Panjgur, about 3,100 ft. (no. M150, M150A); Khudabadan, ¼ mile N. of Panjgur, about 3,100 ft. (no. M177F).—Fl. in March 1918.

Vern. Name: Titmatan (Panjguri Bal.), Sarkok (Zamarani Bal.). Sarkako (Bal.).

Liliaceae.

ASPARAGUS *L.*

Asparagus capitatus *Bak. in Journ. Linn. Soc. XIV, 607.*—Loc.: Nal, 27° 41′ N, 66° 13′ E, about 3,800 ft. (no. 205B); Teghab, 107 miles S. of Kalat, 4,150 ft. (no. 179); Bhani, 131 miles SSW of Kalat, 4,000 ft. (no. 205A).—Fl. in Sept. 1917.

Vern. Name: Avishk (Bal. and Br.), Khakshir (Pers.).

Asparagus racemosus *Willd. Sp. Pl. II, 153.*—Loc.: Hodal Pass (S. side), about 85 miles S. of Panjgur, 2,900 to 2,400 ft. (no. M224).—Fl. in April 1918.

Vern. Name: Kalirkah.

ASPHODELUS *L.*

Asphodelus tenuifolius *Cavan. in Ann. Cienc. Nat. III, 46, t. 27.*—Loc.: Under Harboi, 15 miles ESE of Kalat, 8,300 ft. (no. 49D); Ghulamani Bent, 23 miles N. of Pasni, about 100 ft. (no. M49); 5 miles N. of Mand, about 1,000 ft. (no. M49B); Turbat, 63° 4′ E, 25° 58′ N, about 6,000 ft. (no. M49A).—Fl. in Feb. 1918, Fr. in Feb. and March 1918.

Vern. Name: Serishako (Br.), Pimalo (Bal.).

EREMURUS *Bieberst.*

Eremurus Persicus *Boiss. Diagn. VII, 119.*—Loc.: Harboi, 18 miles ESE of Kalat, 9,000 ft. (no. 49A, 49B).—Fr. in Aug. 1917.

Uses: The leaves are cut up and boiled with oil and ghi, and eaten as a vegetable. (Hotson).

Vern. Name: Sirishako (Br.)

ALLIUM *L.*

Allium scabrellum *Boiss. & Buhsi in Nouv. Mem. Soc. Nat. Mosc. XII (1860) 215.*—Loc.: Harbud, about 53 miles E. of Panjgur, about 3,700 ft. (no. M49C).—Fl. and fr. in April 1918.

Vern. Name: Pimalo, Pimalhe (Br. and Bal.).

Allium? fistulosum *L. Sp. Pl. 301.*—Loc.: Sorgaz on Khozdar River, about 9 miles S. of Khozdar, about 3,800 ft. (no. 363).

Vern. Name: Nargiz.

TULIPA *L.*

Tulipa sp. Loc.: Harboi, 18 miles ESE of Kalat, 9,000 ft. (no. 30). —Fr. in Aug. 1917.

Uses: Eaten by sheep. (Hotson).

Vern. Name: Gwarckh (Br.).

Juncaceae.

JUNCUS *L.*

Juncus glaucus *Ehrh. Beitr. VI, 83.*—Loc.: Gwambok, about 50 miles SE of Panjgur, abont 2,700 ft. (no. M25).—Fr. in Feb. 1918.

Vern. Names: Kul (Bal.).

Juncus maritimus *Lam. Encycl. III, 264.*—Loc.: Panjgur (no. M120C).—Fl. and fr. in May 1918.

Vern. Name: Samar (Bal. and Br.), Samagram, (Panjguri).

Juncus punctorius *L. f. Suppl. 208.*—Loc.: Surab (Jhalarwan). 28° 29′ N, 66° 16′ E, about 7,500 ft. (no. M374).—Fl. in June 1918.

Juncus lampocarpus *Ehr. Calam. n. 126.*—Loc.: Spring on Harboi, 18 miles ESE of Kalat, 8,600 ft. (no. 66).—Fr. in Aug. 1917.

Vern. Name: Dirna Chab (Dir = water), (Br.).

Palmae.

PHOENIX *L.*

Phoenix dactylifera *L. Sp. Pl. 1188.*—Loc.: Chib (Buhda), 63° 8′ E, 26° 19′ N., about 1,600 ft. (no. M123); Nag (W. Kolwa), about 83 miles E by N of Turbat, about 2,300 ft. (no.M123); Chhuttok, 9 miles S. of Kalat, 4,500 ft. (no. 176).—Fl. in March and April 1918.

Vern. Name: Pish (Machi), Hosh (Bal.).

NANNORHOPS *H. Wendl.*

Nannorhops Ritchieana: *H. Wendl. in Bot. Zeit. (1879) 148.*—Loc.: Hills S. of Chambar (Kolwa), 26° 9′ N, 64° 42′ E, about 1,900-2,200 ft. (no. M252).

Vern. Names: Pish-Redag (Bal.).

Typhaceae.

Typha *L.*

Typha angustifolia *L. Sp. Pl. 971.*—Loc.: Shahdadzai, 72 miles S. of Kalat, 5,100 ft. (no. 145); Bhani, 131 miles SSW of Kalat, 4,000 ft. (no. 145A). Fr. in Aug. 1917.

Uses: The heads when ripe are used for stuffing cushions and pillows. (Hotson).

Vern. Name: Kul, Lukh (Br. and Bal.), Lukh (Pers.).

Naiadaceae.

Potamogeton *L.*

Potamogeton oblongus *Viv. Fl. Ital. 2, t. 13.*—Loc.: Chib (Buhda), 63° 8′ E, 26° 19′ N, about 1,600 ft. (no. M126).—Fr. in March 1918.

Alismaceae.

Triglochin *L.*

Triglochin palustre *L. Sp. Pl. 338.*—Loc.: Spring in Harboi, 18 miles ESE of Kalat 8,600 ft. (no. 70A).—Fl. in Aug. 1917.

Gramineae

Echinochloa *Beauv.*

Echinochloa Crus-galli *Beauv. Agrost. 53, t. 11, (1812).*—Loc.: Khozdar, 27° 48′ N, 66° 37′ E, about 4,100 ft. (no. 312A).—Fr. in Sept. 1917.

Vern. Name: Samo (Bal.).

Echinochloa colona *Link Hort. Berol. II, 209.*—Loc.: Tegab, 107 miles S. of Kalat, 4,150 ft. (no. 191). Fl. and fr. in Aug. 1918.

Vern. Name: Samako (Bal.).

Panicum *L.*

Panicum rugosum *L. Mant. I, 29.*—Loc.: Near Ornach, about 3,400 ft. (no. 312). Fr. in Sept. 1917.

Vern. Name: Samo (Bal. and Br.).

Panicum? miliaceum *L. Sp. Pl. 58.*—Loc.: Kalat, about 6,350 ft. (no. M396D). Fr. in July 1918.—Probably cultivated.

Panicum antidotale *Retz Obs. IV, 17.*—Loc.: Rekin (Avaran, Kolwa), 26° 24′ N, 65° 12′ E, about 1,750 ft. (no. M286); Kochan, 122 miles SSW of Kalat, 4,175 ft. (no. 197); Dokop, about 60 miles W. of Turbat, 700 ft. (no. M16); Rodkan (W. Kolwa), about 85 miles E. of Turbat, about 1,800 ft (no. M16A); Chhuttok, 90 miles S. of Kalat, 4,550 ft. (no. 168).—Fl. and fr. in March 1917, April 1918, Dec. 1917.

Vern. Name: Dariagi (Mand Bal.), Gomaz, Gumazg (Bal.), Bershonk.

Setaria *Beauv.*

Setaria glauca *Beauv. Agrost. 51.*—Loc.: Surab, 43 miles S. of Kalat, 5,750 ft. (no. 111). Fl. and fr. in Aug. 1917.

Setaria viridis *Beauv. Agrost. 51.*—Loc: Kalat, about 6,350 ft. (no. M396).—Fr. in July 1918.

PENNISETUM *Pers.*

Pennisetum dichotomum *Del. Fl. Aegypt. 159, t. 8. f. 1.*—Loc.: Dekop, 10½ miles E. of Mand, about 650 ft. (no. M70); Rekin (Awaran, Kolwa), 26° 24′ N, 66° 12′ E, about 1,750 ft. (no. M 16 B); Kochan, 121 miles SSW of Kalat, 4,175 ft. (no. 196).—Fl. and fr. in March and April 1918, Aug. 1917.

Vern. Name: Barshonk, Haden (Br.), Dramshokh (Bal.), Gomaz (Bal. and Br.).

Pennisetum orientale *Rich. in Pers. Syn. I, 72.*—Loc.: Hodal Pass (N. side), about 80 miles, S. of Panjgur, 2,200-2,900 ft. (no. M44A).—Fl. and fr. in April 1918.

Vern. Name: Harnal (Bal.).

Pennisetum cenchroides *Rich. in Pers. Syn. I, 72.*—Loc.: Wahir, 27 miles SSW of Khozdar, about 4,200 ft. (no. 153A); Mangali (Jalarwan), 26° 45′ N, 65° 21′ E, about 2,600 ft. (no. M284A); Dokop, 10½ miles E. of Mand, about 650 ft. (no. M66); Zahren Kahur, 16 miles N. of Parsni, about 200 ft. (no. M 43).—Fl. and fr. in Feb. and March 1918, Sept. 1917.

Vern. Name: Gandil (Gindel less correct) (Br.), Mazardum (Bal.), Putar (Bal. and Br.).

TRAGUS *Haller.*

Tragus racemosus *Scop. Intro. Hist. Nat. 73.*—Loc.: Summit of Burida Pass, 140 miles SSW of Kalat, about 4,250 ft. (no. 212A); Wahir, 25 miles SW of Khozdar, 4,200 ft. (no. 371).—Fl. and fr. in Aug. and Oct. 1917.

Vern. Name: Mashna (Habi Br.).

IMPERATA *Cyrill.*

Imperata arundinacea *Cyrill. Pl. Rar. Neap. Fasc. II, 26, t. 11.*—Loc.: Khudabadan, ¼ mile N. of Panjgur, about 3,100 ft. (no. M195).—Fl. and fr. in March 1918.

Vern. Name: Drug (Bal.)

ERIANTHUS *Michx.*

Erianthus Griffithii *Hook f. in Hook. f. Fl. Brit. Ind. VII, 122.*—Loc.: Gwambuk, about 50 miles SE of Panjgur, about 2,700 ft. (no. M 24).—Fl. and fr. in Feb. 1918.

Vern. Name: Kash (Bal. and Br.).

Erianthus Ravennae *Beauv. Agrost. 14.*—Loc.: Bhani, 131 miles SSW of Kalat, 4,000 ft. (no. 165 A); Chhuttok, 90 miles S. of Kalat, about 4,550 ft. (no. 165).—Fl. and fr. in Aug. 1917.

Vern. Name: Kik (Bal. and Br.).

ELIONURUS *Humb & Bonpl.*

Elionurus hirsutus *Munro ex Benth. in Journ. Linn. Soc. XIX (1881) 68.*—Loc.: Rekin (Awaran, Kolwa), 26° 24′ N, 65° 12′E, about 1,750 ft. (no. M212C)—Fl. and fr. in April 1918.

Vern. Name: Gorkah (Bal. and Br.).

Andropogon *L.*

Andropogon foveolatus *Del. Fl. Egypt. 16a, t. 8, f.* 2.—Loc.: Rekin (Awaran, Kolwa), 26° 24′ N, 65° 12′ E, about 1,700 ft. (no. M287); Zahrew Kahur, 16 miles N. of Pasni, about 200 ft. (no. M40A).—Fl. and fr. in Feb. and April 1918.

Vern. Name: Sibr, Gandil (Bal. and Br.).

Sorghum *L.*

Sorghum halepense *Pers. Syn. I, 101.*—Loc.: Quetta.

Chrysopogon *Trim.*

Chrysopogon serrulatus *Trim. in Mem. Acad. Petersb. ser. 6, 11 (1833) 318.*—Loc.: Rekin (Awaran, Kolwa), 26° 24′ N, 65° 12′ E, about 1,750 ft. (no. M284). Fl. and fr. in April 1918.

Vern. Name: Potar (Bal.).

Dicanthium *Willem.*

Dicanthium annulatum *Stapf.*—Loc.: Nagak (W. Kolwa), about 87 miles E. by N. of Turbat, about 2,400 ft. (no. M230); Khozdar (no. 312A).—Fl. and fr. in April 1918.

Vern. Name: Samo.

Cymbopogon *Sprengel.*

Cymbopogon Iwarancusa *Schult. Mant. II, 458.*—Loc.: Kochan, 122 miles SSW of Kalat, 4,175 ft, (no. 162A); Harbud, about 155 miles E. of Panjgur, about 3,700 ft. (no. 213B); Awaran, Kolwa, 26° 24′ N, 65° 12′ E, about 1,750 ft, (no. M281); Drakalo, 12 miles SSW of Wad, about 4,900 ft. (no. 162B.).—Fl. and fr. in April 1918, Aug. and Sept. 1917.

Uses: When a man has fever, a large quantity of this grass is collected and made into a bed. He lies on it and at once begins to sweat. The roots are said to be sweet-scented. (Hotson).

Vern. Name: Have (Br.), Haveh (Br. and Bal.).

Cymbopogon Martini *Stapf.*—Loc.: Kanoji, 47 miles N. of Las Bela, about 3,200 ft. (no. 386).—Fl. and fr. in Oct. 1917.

Vern. Name: Putar (Br.).

Aristida *L.*

Aristida Adscenscionis *L. Sp. Pl. 82 (excl. Syn. Sloane.)*.—Loc.: Rekin Awaran, (Kolwa) 26° 24′ N, 65° 12′ E, about 1,750 ft. (no. M285).—Fl. and fr. in April 1918.

Vern. Name: Lash (Br.)

Aristida mutabilis *Trin. & Rupr. in Mem. Acad. Petersb. ser. 6, VII (1849) 150 (excl. var. aequilonga)*.—Loc.: Gili (Jar.), about 100 miles SSW of Kalat, about 2,000 ft. (no. 59A).—Fl. and fr. in Sept. 1917.

Vern. Name: Gadbahi (Br.).

Stipa *L.*

Stipa orientalis *Trin. ex Ledeb. Fl. Alt. I, 83.*—Loc.; Harboi, 18 miles ESE of Kalat, 9,000 ft. (no. 34).—Fl. and fr. in Aug. 1917.

Uses.— : Eaten by animals.

Vern. Name : Gasht (Br.).

Stipa pennata *L. Sp. Pl. 78.*—Loc.: Chhuttok, 90 miles S. of Kalat, about 4,550 ft. (no. 162); Gwambuk, about 50 miles SE of Panjgur, about 2,700 ft. (M 29).—Fl. and fr. in Aug. 1917.

Uses : Reputed to be the best grazing grass on the hills (Hotson).

Vern. Name : Haveh (Br.), Mazh (Bal.).

Polypogon *Desf.*

Polypogon monspeliensis *Desf. Fl. Atl. I, 66.*—Loc.: Nag (W. Kolwa), about 83 miles E. by N. of Turbat, about 2,300 ft. (no. M24B); Mazarjuh (Gidar, Jalarwan), 28° 11′ N, 66° 2′ E, about 5,200 ft. (no. M254); Panjgur, about 3,200 ft. (no. M124A); Chib (Buhda) 63° 8′ E. 26° 19′ N, about 1,600 ft.—Fl. and fr. in March, April and June 1918.

Vern. Name : Jaudal (Bal. and Br.), Narmo (Kechi, Makrani Bal.), Phulko (Panjguri Bal.)

Sporobolus *Br.*

Sporobolus arabicus *Boiss. Diagn. Pl. Or. ser. I, XIII, 47.*—Loc.: Teghab, 107 miles S. of Kalat, 4150 ft. (no. 192); Nagak (W. Kolwa), about 87 miles E. by N. of Turbat, about 2,400 ft. (no. M 229). — Fl. and fr. in April 1918, Aug. 1917.

Vern. Name : Lash (Br. and Bal.).

Agrostis *L.*

Agrostis verticillata *Vill. Fl. Delph. 74.*—Loc.: Iskalku, 7 miles E. of Kalat, 7,500 ft. (no. 86); Khudabadan, ¼ mile N. of Panjgur, about 3,100 ft. (no. M 189).—Fl. and fr. in March 1918, Aug. 1917.

Vern. Name : Tusg (Bal.).

Avena *L.*

Avena Cavanillesii *Koch Syn. Fl. Germ. ed. 1, 1, 797.*—Loc.: Quetta.

Cynodon *Pers.*

Cynodon dactylon *Pers. Syn. I, 85.*—Loc.: Panjgur (no. M428). Kalat, about 6,350 ft. (no. M 396 A). Fl. and fr. in May and July 1918;

Vern. Name : Shez (Panjguri Bal.), Milinu.

Chloris *Sw.*

Chloris villosa *Pers. Syn. I, 87.*—Loc.: Chhuttok, 99 miles S. of Kalat, about 4,550 ft. (no.161); summit of Burida Pass, 140 miles SSW of Kalat, about 4,250 ft. (no. 212).—Fl. and fr. in Aug. 1917.

Vern. Name : Gashd, Mashna Chab (Br.), Kohi Chab (Bal.).

ELEUSINE *Gaertn.*

Eleusine flagellifera *Nees in Linnaea XIV* (1842) 220.—Loc.: Zahrin Kahur 16 miles N. of Pasni, about 200 ft. (no. M 40). Fl. and fr. in Feb. 1918.

Vern. Name: Gandil (Bal. and Br.).

ARUNDO *L.*

Arundo Pliniana *Turra, Farset.* 11.—Loc.: Kori Kaur, W. of Ornach (no. 310)—Fl. in Sept. 1917.

Vern. Name: Nal.

PHRAGMITES *Trin.*

Phragmites communis *Trin. Fund. Agrost. 134.*—Loc.: Ornach, 3,080 ft. (no. 123A).—Fl. and fr. in Sept. 1917.

Vern. Name: Nalinchk.

KOELERIA *Pers.*

Koeleria phleoides *Pers. Syn. I, 97.*—Loc.: Quetta.

ERAGROSTIS *Beauv.*

Eragrostis papposa *Steud. Nom. ed. 2, I, 564.*—Loc.: Surab, 43 miles S. of Kalat, 5,750 ft. (no. 112); Quetta; Kalat, abount 6,350 ft. (no. M 396C).—Fl. and fr. in July 1918, Aug. 1917.

DESMOSTACHYA *Stapf.*

Desmostachya bipinnata *Stapf in Dyer Fl. Cap. VII, 632 (1900).*—Loc.: Shahdadzai, 72 miles S. of Kalat, 5,100 ft. (no. 135B). —Fl. and fr. in Aug. 1917.

Vern. Name: Drak (Br. etc.).

AELUROPUS *Trin* (partim).

Aeluropus arabicus *Steud. Nom. ed. 2, I. 30.*—Loc.: Karki, 21 miles NE of Buhda, about 1,600 ft.

Vern. Name: Kandar (Br. and Bal.), Baun (Cechi Br).

SCHISMUS *Beauv.*

Schismus marginatus *Beauv. Agrost. 74, t. 15, f. 4.*—Loc.: Quetta.

AGROPYRUM *J. Gaertn.*

Agropyrum repens *Beauv. Agrost. 102.*—Loc.: Kalat, about 6,350 ft. (no. M396).—Fl. and fr. in July 1918.

Vern. Name: Milinj (Br.)

Agropyrum longe-aristatum *Boiss. Fl. Or. I, 660.*—Loc.: Turbat, 63° 4′ E, 25° 58′ N, about 600 ft. (no. 55).—Fl. and fr. in Feb. 1918.

Gnetaceae.

EPHEDRA *L.*

Ephedra foliata *Stapf in Denkschr. Mathem.-Naturw. Classe Kais. Akad. Wiss. (1889), 49, t. 2 and 10, f. 1—11.*—Loc.: Pusht Kuh

(Kharan), about 26° 57′ N, 65° 12′ E, about 3,500 ft. (no. M302A).—Fr. in April 1918.

Vern. Name: Humuk (Bal.).

Ephedra intermedia *Stapf l. c. 61, t. 2 and 15, f. 1—9.*—Loc.: Harboi, 18 miles ESE of Kalat, 9,000 ft. (no. 23); Kalgali Jaur (Kharan), 22° 1′ N, 65° 54′ E, about 5,400 ft. (M348); Hushtar Rahi Kaur, 160 miles S. of Kalat, about 3,700 ft. (no. 304).—Uses: Used for tanning leather.

Vern. Name: Narom, Naromb (Br.), Hom (Bal.).

Ephedra nebrodensis *Stapf l. c. 77, t. 3, XX. f. 1—7.*—Loc.: Bhani, 131 miles SSW of Kalat, 4,000 ft. (no. 205).

Vern. Name: Avishk (Br.).

Coniferae.

Juniperus L.

Juniperus macropoda *Boiss. Fl. Or. V. 709.*—Loc.: Harboi, 18 miles ESE of Kalat, 9,000 ft. (no. 18, 18A, 18B).—Fr. in Aug. 1918.

Uses: The berries are boiled and the juice is very good in diseases of the chest, causing profuse perspiration. They are greatly exported to Sind for use as medicine. The leaves are eaten by camels. and the berries by chikor.

THE END

CURRENT LITERATURE.

Physiology

MacDougal, D. T., H. M. Richards, & H. A. Spoehr. Basis of succulence in plants. *Bot. Gaz. 67: 405-416. 1919.*

Succulence is defined as an exaggerated development of the parenchymatous regions of the plant. The masses of thin-walled cells become permanently distended and turgid. Succulent plants are characteristic of deserts and of salty areas along seashores. All attempts to connect the origin of succulence with the presence of salts in the soil, or with high acidity in the plant tissues, or with purposeful development of water-storage tissue have been inadequate.

The authors found a plant, *Castilleja latifolia*, becoming a succulent on dry bluffs along the coast of California, but producing thin leaves in places with better water supply. The thin leaves show double the acidity of the succulent leaves. From a large series of experiments, analyses, and observations, they conclude that with scarcity of water in the cells, polysaccharides are transformed into pentosans. The polysaccharides show little imbibation, while the pentosans show an enormous capacity to imbibe water and to swell. The result is the production of a succulent plant, and as the reaction is irreversible, the succulence is permanent. They believe that the high acidity is nothing more than a characteristic of plants which have a metabolic complex favorable to the formation of pentosans, and to the development of succulence under certain conditions of environment.

WINFIELD DUDGEON.

Gray, John and George J. Pierce. The influence of light upon the action of stomata and its relation to the transpiration of certain grains. *Am. Jour. Bot. 6 : 131—155. 18 figs. 1919.*

It is commonly accepted that stomata act as the main regulators of transpiration, and that their movement is due to changes in the turgidity of the guard cells. From a study of a number of cultivated and wild grasses the authors conclude that while "turgidity of the guard cells is a necessary factor in producing and maintaining their elasticity.....the direct and indispensible agent in controlling the opening and closing of the stomata is sunlight, which acts as a stimulus on the guard cells themselves." They find that the stomata do not maintain sufficient turgidity to be affected by light when the soil moisture falls below a certain specific amount, but no matter how well watered the plant is, the stomata do not open on cloudy days. When sufficient moisture is present, the opening of the stomata follows very closely the incidence of sunlight.

Their method was to examine the leaves under a microscope while still attached to the growing plant. This involves minimum disturbance of the stomata, and permits repeated examination of the same leaf, and even of the same stomata, under varying conditions.

WINFIELD DUDGEON.

Small, James "The Chemical Reversal of Geotropic Response in Roots and Stems"—*The following abstract of a paper read before the Linnean Society, March 18, 1920, is taken from the minutes of the meeting.*

When roots are placed horizontally in a moist atmosphere rendered very faintly alkaline by ammonia vapour they tend to grow upwards. When stems are treated in a similar way with acetic acid vapour they tend to grow downwards.

These experiments, illustrated by photographic lantern-slides, form preliminary confirmation of the following theory of geotropic curvature, which has been elaborated as a co-relation of previous work on the electrical conductivity of roots with data accumulated by other investigators.

The outer zone of the protoplasm in the cells of the apical meristem is an emulsion with a continuous phase of colloidal aqueous solution and a disperse phase of protein or protein-lipoid particles, which show Brownian movement and carry an electropositive charge when the hydrion concentration of the continuous phase is higher than the isoelectric point of the vegetable proteins, or an electornegative charge when that hydrion concenteration is lower than the isoelectric point of the proteins. The continuous phase or medium in the root is relatively acid and that in the stem is relatively alkaline.

Creaming of the emulsion under the influence of gravity causes differences of potential in the apex of root and stem, which produce electric currents. These produce differences in permeability, turgor, and rate of growth. The direction of these currents is determined by the positive charge in the root and the negative charge in the stem with corresponding downward or upward curvature.

The reversal of curvature in the experiments is due to the reversal of the electrical charges on the particles of the disperse phase, which is caused by the changes in the relation of the hydrion concentrations to the isoelectric point of the proteins. This theory explains practically all the details of known geotropic phenomena, including the orientation of the secondary and tertiary branches of roots and stems. It has very wide applications to cytolysis, the stimulus response ratio of the Weber Law, acid-tolerant and calcifuge species, immunity from and liability to attack by bacteria and fungi, the development of intumescences, the effects of acids, alkalies, and salts on plants and animals in general and on the permeability of protoplasm in particular, and possibly also to epharmonic variations. It provides on explanation, not only for the normal polarity of growth in the plant, but also for the changes in geotropic response and in colour which occur in flower-buds and other organs.

Indications have been obtained that the Co^2 balance in stem and root is the chief factor governing the differentiation in hydrion concentration, and also that phyllotaxis can be explained in terms of the potential differences postulated.

Heredity

White, Orland E. Breeding new castor beans. *Jour. Heredity 9: 195—200. 5 figs. 1918.*

The author calls attention to the desirability of developing improved

strains of the common castor bean (*Ricinus communis*). The paper is of great interest because it calls attention to the fact that the plant is very favorable material for genetical work. There is a large number of contrasting and easily recognizable characters, such as color of stem, foliage, and seed coats; presence or absence of glaucescence; dehiscent or indehiscent capsules; height of plant; size and compactness of fruiting spike; time of maturity; size and shape of seeds; oil and "acid" content of seeds, etc. The ordinary Indian field presents a hopeless mixture of these characters. Since the plant is monoecious, and the staminate and carpellate flowers are segregated in the inflorescence, it is quite easy to conduct controlled pollination experiments. Ricinus should prove very useful for demonstrating to college classes the outstanding facts of inheritance.

WINFIELD DUDGEON.

Hepaticae

Campbell, D. H. Studies in some East Indian Hepaticae. (Calobryum Blumei). *Annals of Botany, Jan. 1920.*

The writer describes the structure and development of the curious liverwort *Calobryum Blumei*. The plant has a much branching prostrate stem like a rhizome without rhizoids which gives rise to erect aerial leafy shoots sympodially. The leaves are arranged radially in three rows, though one of the rows has often smaller leaves. The leaves are thicker at the base than higher up. The stem grows by means of a tetrahedral apical cell, and it has a large celled cortex and a central cylinder with narrow and elongated cells. Mucilage hairs are present in almost all parts of the plant. Antheridia and archegonia occur separately in clusters and are surrounded by large leaves. Development of both is very variable. That of the antheridium is as a rule astonishingly like the development of the archegonium. The stalk of the antheridium consists of four rows of cells and the structure of the latter is like that of other liverworts. The development of the sperms is as usual in liverworts. The apical cell is used up in the formation of the archegonia. The venter is formed of two layers of cells in the mature archegonium, and the neck consists of four rows of cells. The conclusion is drawn that the male and the female organs are homologous. The development of the embryo, so far as seen, was like that in the other Jungermanniales. There is a long seta, and an elongated capsule with a single layer of cells forming its wall and a beak at the apex. Dehiscence by a long slit along one side. Elaters with a double spiral. There is a massive calyptra.

The conclusion is that the separation of *Calobryum* along with *Haplomitrium* into a family, the Calobryaceae, is entirely justified. The distribution of the genus shows that it was more generally distributed in former times.

S. R. K.

Mosses

Brown, Mabel M. The development of the gametophyte and the distribution of sexual characters in Funaria hygrometrica. *Am. Jour. Bot. 6: 387-400. pl. 1. 1919.*

Conflicting statements have been made in the literature about the distribution of sex organs in this moss. Many have claimed that it is strictly

dioicous; more recent work has tended toward the conclusion that for the most part it is monoicous. Miss Brown made an immense number of single spore cultures in pots, and studied the behavior in the formation of sex organs. Some of the cultures ran for two years. She concludes that *Funaria hygrometrica* is strictly monoicous, but with considerable variation in the position of the sex organs. Usually the antheridia appear first, and at the apex of the main axis, while the archegonia develop later at the ends of branches. In some cases the gametophore is unbranched and produces either antheridia or archegonia; when branches are formed they may bear either kind of sex organs. But in every case the spores, protonemata, and gametophores are bisexual in their potentialities.

WINDFIELD DUDGEON.

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EDITORIAL RETROSPECT

Eight months ago the Journal was launched with a mixture of hope and doubt, but a determination to succeed, and it may not be without interest briefly to review its progress. The object, as explained in the circular inviting contributions, and in the first editorial. was to be the publication, in the first place, of original botanical work done in India or on Indian plants, which would not naturally appear in the existing, somewhat technical, journals of this country and, in the second, of abstracts or reviews of other papers likely to be of interest to workers in India. Though supported by nearly every important botanist in India, the proposal met with misgivings from several who thought the "times were not yet ripe." "You will be fifty years in advance of your time" wrote one friend; "It may start all right but will soon fizzle out" said another.

The idea was for quite a moderate journal of about 24 pages, but to appear monthly, so as to allow of rapid publication of work. The first number appeared in September, and except in February, when pressure of other work at the Press prevented publication, and the next was therefore a 'double number', the issues have been monthly. The present and the January issues are also 'double', so that in the eight months ten numbers have appeared with an average of over thirty pages of original matter and diagrams and about four of abstracts to each. The original papers have been on nearly every branch of pure botany, *i.e.*, on Fungi, Algae, Liverworts, Mosses, Gymnosperms, the taxonomy of flowering plants, General and Physiological Histology and Morphology, Physiology, Oecology and a Systematic Flora of a country. Abstracts and reviews have appeared of over 50 papers and books, and occupied 40 pages of small type.

All this has been possible only with the active co-operation of botanists in India who have not only subscribed to the Journal, but also contributed to its pages: and it proves, I think we may claim, that the Journal has met a need, that botanical work in India was advanced enough for it, that the times were ripe. It remains to disprove the pessimist and keep the Journal alive. I have no fear about this. The Journal has started successfully, and won't fizzle out. It now circulates all over India,—though Bengal rather lags behind the other Provinces—in Canada, the U.S.A., England, Italy, Ceylon, Singapore, Australia and even Fiji: and without doubt the close of another year will see it covering a wider area and with

many more readers. Contributors may therefore feel assured that their work will not be lost to the scientific botanical world.

At the same time the Journal does not quite pay its way and has had financial assistance from the generous guarantor, Mr. T. R. D. Bell, C.I.E., who recently retired from the Office of Chief Conservator of Forests, Bombay Presidency. We need therefore all the subscriptions we can get, and we look to subscribers not only to continue their support but also to induce others to join.

P. F. Fyson.

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THE ORGANIZATION OF THE INDIAN BOTANICAL SOCIETY.

There has long been the need for organization of the scattered and isolated botanical interests of India. At the Nagpur meeting of the Indian Science Congress in January, 1920, the Botany Section decided to organize an Indian Botanical Society. A Committee consisting of Prof. W. Burns, D.Sc., of the College of Agriculture, Poona; Prof. P. Brühl, Ph.D., of the University College of Science, Calcutta; Prof. Shiv Ram Kashyap, M.Sc., of the Government College, Lahore; Rai Bahadur K. Rangachari, M.A., L.T., of the Agricultural College, Coimbatore; Prof. Borbal Sahni, D.Sc., then of Benares Hindu University, Benares; and Prof. Winfield Dudgeon, Ph.D., of Ewing Christian College, Allahabad, Chairman, was constituted to carry out the details of organization. The membership of the Society has now (December, 14, 1920) reached 71, and includes men engaged in all branches of botanical service from all parts of the country.

When the membership had reached 40, an election was held by correspondence, and the following officers were elected :—Dr. Winfield Dudgeon, President; Dr. W. Burns, Vice-President; Prof. Shiv Ram Kashyap, Secretary-Treasurer; Dr. Borbal Sahni, Councillor for two years and Rai Bahadur K. Rangachari, Councillor for one year. The President and Vice-President will serve through 1921, when the President will become a Councillor for two years; the Secretary-Treasurer is elected for a period of three years. The Officers and Councillors will constitute an Executive Committee to transact the business of the Society between annual meetings.

The purposes of the Society are several, though it may take years to realize some of them. The Society should promote a feeling of fellowship among Botanists, and draw them together for mutual benefit; help to improve the quality and content of botanical instruction in the various colleges and universities, provide Botanists an organized means for dealing with other organizations; and promote and encourage research in Botany, by advice and encouragement to beginners in research, by organizing botanical trips and expeditions of various kinds; and perhaps finally by establishing one or more Biological Stations in suitable locations. It should provide a central exchange for aiding Botanists in securing teaching and other appointments, for ideas, opinions, methods, and information generally, and for specimens, slides, research material, etc.; and finally, it should make more available to members the scattered and insufficient botanical literature that reaches India.

FEB 23 1921

Conditions for membership have been fixed so that all who are truly interested in any phase of Botany are eligible. "Membership shall be open to all graduates who are interested in any phase in Botany; to non-graduates who have pursued advanced studies in Agricultural, Forestry, or other institutions, or who have distinguished themselves in research; and to such others as in the judgement of the Society are worthy of membership." There is no initiation fee. The annual dues have been fixed at Rs. 5, or when combined with a subscription to the Journal of Indian Botany, at Rs. 2-8-0. It is hoped in this way to encourage members to give their support to the only strictly botanical Journal in India.

All who join before the meeting of the Science Congress at Calcutta, January 31 to February 5, will be considered as Charter Members. Anyone who is eligible may become a Charter Member by remitting his dues to the Chairman of the Committee of Organization.

The Society will be affiliated with the Indian Science Congress in some way yet to be determined, and during the Calcutta meetings of the Congress the first meetings of the Society will be held.

Note to Contributors

It would greatly assist the Honorary Editor if the following rules are kept in mind by Contributors :—

All matter for the printer should be typed and on one side of the paper only. The name of a genus should begin with a capital letter, but that of the species only when it is adapted from a proper name. No comma should be put in after the specific name and before that of the founder of the species. The Editor will see to the type.

Illustrations in line should be drawn in India ink on smooth paper or card, and will reproduce best if at least twice as large as they will appear in the Journal. Photographs, for reproduction by half-tone process must be on glossy paper and should be strong bright prints. Good results cannot be obtained from over-exposed Photographs or weak prints.

Abstracts of papers in other Journals should begin with the author's name and initial, followed by the title of his paper and where it is published: the abstract itself beginning a new line.

Ten reprints of original papers will be supplied free and more may be had on payment if asked for at the time the contribution is sent in.

The Journal of Indian Botany will be sent post free to places in India for Rs. 10 per annum: and to places outside India for Rs. 10-6-0 which, at the present rate of exchange, corresponds roughly to £1-5-0.

Subscriptions should be sent to the Superintendent, Methodist Publishing House, Mount Road, Madras, S. India.

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TEMPORARY EDITOR

E. BLATTER, S.J.,

St. Xavier's College, Bombay



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All contributions and matter relating to this Journal should be sent to the Editor,

P. F. Fyson,
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Intending Contributors are requested to see the note on page 3 of this cover.

The Annual Subscription to the Journal of Indian Botany is to places in India Rs. 10, and to places outside India £1-1-0.

Subscriptions should be sent to the Agent, Methodist Publishing House, Mount Road, Madras, S. India.

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THE
Journal of Indian Botany.

The Editor regrets that owing to a long strike of printers which left the presses so congested with work that it was difficult to get matter through, there have been long delays in the appearance of this Journal ; but hopes that from now onwards it will appear with reasonable regularity.

herbaceous. Mesophyll composed of arm-palisade cells. Clothing hairs absent. Glandular hairs depressed, biseriate and spherical. Stomata elevated or depressed. Bundles of acicular crystals found near veins, in cortex and in pith. Collonchyma not doveloped in cortex. Wood composite. Medullary rays uniseriate. Endodermis formed of thin-walled cells. Pith consisting of thin-walled cells.

Pulicaria angustifolia *DC.*—Figs. 171, 172. Herbaceous. Stomata elevated. Mesophyll consisting of arm-palisade cells. Clothing hairs in the form of flagellum trichomes. Glandular hairs depressed, biseriate and spherical. Collenchyma sub-epidermal. Wood composite and deeply lobed on the inner side. Pith formed of thin-walled calls.

Pulicaria rajputanae *Blatt. and Hall.*—Figs. 173, 174, 175, 176, 177. Woody. Stomata depressed. Mesophyll isobilateral. Secretory

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Journal of Indian Botany.

VOL. II. JANUARY, 1921. NOS. 1 & 2.

THE PHYSIOLOGICAL ANATOMY OF THE PLANTS OF THE INDIAN DESERT

BY

T. S. SABNIS, B.A., M.Sc.

St. Xavier's College, Bombay.

(*Continued from Vol. I, p. 287.*)

COMPOSITAE

Vernonia cinerascens *Schult.*—Figs. 163, 164, 165, 166. Woody. Mesophyll isobilateral. Stomata depressed. Clothing hairs two-armed. Glandular hairs consisting of a spherical head and of a stalk-cell or of a short stalk. Collenchyma not developed in cortex. Wood composite. Medullary rays 1-3 seriate. Pith formed of lignified cells.

Pegolettia senegalensis *Cass.*—Figs. 167, 168, 169, 170. Herbaceous. Mesophyll composed of arm-palisade cells. Clothing hairs absent. Glandular hairs depressed, biseriate and spherical. Stomata elevated or depressed. Bundles of acicular crystals found near veins, in cortex and in pith. Collonchyma not doveloped in cortex. Wood composite. Medullary rays uniseriate. Endodermis formed of thin-walled cells. Pith consisting of thin-walled cells.

Pulicaria angustifolia *DC.*—Figs. 171, 172. Herbaceous. Stomata elevated. Mesophyll consisting of arm-palisade cells. Clothing hairs in the form of flagellum trichomes. Glandular hairs depressed, biseriate and spherical. Collenchyma sub-epidermal. Wood composite and deeply lobed on the inner side. Pith formed of thin-walled calls.

Pulicaria rajputanae *Blatt. and Hall.*—Figs. 173, 174, 175, 176, 177. Woody. Stomata depressed. Mesophyll isobilateral. Secretory

cells found in mesophyll. Clothing hairs in the form of flagellum trichomes. Glandular hairs biseriate and club-shaped. Collenchyma composite and sub-epidermal in the axis. Wood composite. Medullary rays 1-3 seriate. Medullary xylem bundles present. Pith formed of cells with thickened and lignified walls. Some of the pith cells holding dark granular contents and also rounded bodies.

Eclipta erecta *L.* Figs.—178, 179. Very herbaceous. Stomata depressed. Mesophyll composed of arm-palisade cells. Clothing hairs absent. Glandular hairs depressed, biseriate and spherical. Collenchyma sub-epidermal in the axis. Wood composite and deeply lobed on the inner side. Pith formed of thin-walled cells.

Echinops echinatus *R.*—Figs. 180, 181, 182. Very herbaceous. Stomata elevated. Mesophyll formed of palisade tissue on the adaxial side and of arm-palisade tissue on the abaxial side. Clothing hairs in the form of flagellum trichomes. Glandular hairs long-stalked and with an irregularly divided spherical head. Collenchyma sub-epidermal in the axis. Endodermis formed of large thin-walled cells. Wood composed of large xylem bundles alternating with small ones. Pith consisting of thin-walled cells.

Volutarella divaricata *Bth.*—Fig. 183. Very herbaceous. Stomata elevated. Mesophyll isobilateral. Clothing hairs absent. Glandular hairs long-stalked and with a head irregularly divided. Collenchyma sub-epidermal in the axis. Wood more or less composite. Pith formed of thin-walled cells.

Dicoma tomentosa *Cass.*—Figs. 184, 185, 186, 187, 188, 189. Herbaceous. Stomata depressed. Mesophyll composed of palisade tissue on the upper side and of arm-palisade tissue on the lower. Clothing hairs in the form of uniseriate flagellum trichomes. Glandular hairs depressed, uniseriate and spherical. Collenchyma strengthening the ribs of the axis. Wood not composite. Pith consisting of thin-walled cells.

Launaea chondrilloides *H.f.*—Figs. 190. Herbaceous. Stomata depressed on the leaf but elevated on the axis. Mesophyll formed of arm-palisade cells. Clothing and glandular hairs absent. Collenchyma not developed in cortex. Wood not composite. Assimilatory tissue in the axis formed of palisade tissue. Pith formed of thin-walled cells.

Structure of the Leaf:—The epidermal cells are alike on both the sides and have the outer walls greatly thickened and convexly arched outwards. The lateral walls are thin and undulated; inner walls are usually thickened. The cells at the margin are rounded and have outer walls toothed in *D. tomentosa* and papillose in other members.

The epidermal cells of the mid-rib are much smaller than those on the other portions of the leaf-blade. The stomata are usually equally distributed on both the surfaces. Guard-cells are elevated in *Pegolettia senegalensis* (fig. 167), *Pulicaria angustifolia*, *E. echinatus* and *V. divaricata*, so that the front cavity is on a level with the surface. The guard-cells are situated in the plane of the surrounding cells in other members, so that the front cavity is placed in a depression formed by the outer thickened epidermal walls (figs. 174, 184, 190). In *Pegolettia senegalensis* elevated stomata occur side by with depressed ones (fig. 167).

The mesophyll in *D. tomentosa* and *E. echinatus*, is composed of palisade tissue on the adaxial side and of arm-palisade tissue on the abaxial side; it is isobilateral in *V. cinerascens*, *P. rajputanae* and *V. divaricata*. In other members it consists of arm-palisade cells with horizontally elongated cells in the middle.

The veins are embedded except those of the mid-rib which are vertically transcurrent above and below by collenchyma. In *V. cinerascens* there are a few stone-cells on the upper side of the veins. The veins of the mid-rib are quite prominent beneath and are strengthened on the lower side by arcs of stone-cells.

Internal secretory organs are not found except in *P. rajputanae* in which secretory cavities occur one on either side of the veins of the mid-rib, with a lining layer of cells and with yellowish contents. Oxalate of lime occurs in *P. senegalensis*, in the form of bundle of acicular crystals near the veins, in cortex and in pith.

Hairy covering on the leaf and axis consists of clothing and glandular hairs. Clothing hairs, termed "flagellum-hairs" consist of a uniseriate stalk and of a flagellum-like terminal cell in *P. angustifolia*, *P. rajputanae*, *E. echinatus* and *D. tomentosa*; in *E. echinatus* the long terminal cell is bent on the stalk as on a hinge. In *V. cinerascens* (fig. 164) there are two-armed hairs, consisting of a uniseriate stalk and of a terminal unicellular two-armed cell; the arms are unequal. The glandular hairs are of various shape. They are placed in epidermal depressions and consist of a short uniseriate stalk and of a large biseriate head in *P. senegalensis* (fig. 167), *P. angustifolia*, (fig. 172) and *E. erecta*. The external glands, in *E. echinatus* (fig. 181) and *V. divaricata*, consist of a long uniseriate stalk and of a head irregularly divided; besides these there are in *E. echinatus* (fig. 179) spherical glands which are uniseriate, depressed and with thickened and verrucose walls. They are club-shaped in *P. rajputanae* (fig. 176) and are long-stalked, uniseriate and with the terminal cell much dilated to form the head in *V. cinerascens* (fig. 165, 166). Uniseriate, spherial and depressed glandular hairs are found in *V. cinerascens*

(fig. 163) and *D. tomentosa* (fig. 186); secretion collects below the cuticle which is swollen like a bladder. Besides the biseriate spherical glands, there are other glandular hairs on the axis of *P. senegalensis*, which are composed of a long, broad, biseriate stalk and of a small biseriate head (fig. 170); there are also peculiar hairs with a long multicellular stalk and with a small biseriate head, occurring in groups on the lower side of the mid-rib of the leaves (fig. 169). External glands are more numerous on the lower surface of the bifacial leaves; they check transpiration by pouring their secretion on the surface. The greater abundance of stomata on the lower surface brings about the development of a dense covering of clothing and glandular hairs on the lower surface.

Structure of the Axis.—The epidermis is one layered, the outer and inner walls being equally thickened. The former are convexly arched outwards. Lateral walls are thin and undulated. Guard-cells are elevated and the front cavity is on a level with the surface in *P. angustifolia*, *E. echinatus*, *D. tomentosa* (fig. 188) and *L. chondrilloides*; in other members guard-cells are situated in the same plane as that of the surrounding cells and the front cavity is situated in a depression produced by outer thickened epidermal walls. The elevated position of the stomata is necessitated by the abundance of thin-walled cortical parenchyma.

The primary cortex is characterised by the assimilatory tissue formed either of palisade tissue as in *L. chondrilloides* or of chlorenchyma as in other members. Collenchyma is developed in the ribs of *E. echinatus*, *V. divaricata* and *D. tomentosa*, while in *P. rajputanae* (Fig. 189 Cl) there occurs a continuous sub-epidermal ring of collenchyma. Endodermis is differentiated in *P. senegalensis*, *E. echinatus* and *D. tomentosa* (fig. 189), and it consists of thin-walled tabular cells with perhaps a water-storing function.

The pericycle consists of a more or less composite ring of groups of stone-cells with small lumina in all members except in *E. echinatus*, where it is formed of stone-cell groups separated by bast fibres (fig. 182). The arrangement of stone-cell groups in *D. tomentosa* is isobilateral, larger groups being developed on the side exposed to the direction of the prevailing winds.

Name of Species.	Structure of Wood.	Vessels.			Medullary rays.		Interfascicular wood prosenchyma.		General remarks.
		Abundance.	Size of Vessels.	Arrangement of Vessels.	Size.	Abundance.	Lumen.	Abundance.	
V. cinerascens.	Composite	Few	Large	Rows	1-3 seriate	Numerous	Small	Extensive	Woody
P. senegalensis.	,,	Numerous	Small	In groups of many rows	Uni-seriate	,,	,,	,,	Woody
P. angustifolia.	Composite and deeply lobed on the inner-side	,,	Large	,,	Absent	,,	,,	,,	Wood narrowed on the lower side of the inclined axis
P. rajputanae.	,,	,,	,,	,,	1-3 seriate	Numerous	Large	,,	Occurrence of medullary vascular bundles between larger bundles
F. erecta.	Composite	,,	Small	,,	Absent	Absent	Small	,,	
E. echinatus.	Composed of larger bundles alternating with smaller bundles. Larger bundles projecting deeply into pith	,,	Large	,,	,,	,,	Absent	absent	Bundles connected by thick-walled small-celled pith
V. divaricata.	Composite	,,	,,	,,	,,	,,	,,	,,	Quite herbaceous
D. tomentosa.	Composed of large and small bundles	,,	Large in large bundles and small in small bundles	,,	,,	,,	Large	Not extensive	,,
L. chondrilloides.	Composed of bundles	,,	Large	In groups of two rows	,,	,,	,,	Absent	

The wood is composed of xylem bundles or forms a composite hollow cylinder, as will be seen from the tabular form. Vessels have simple perforations. The interfascicular wood prosenchyma is well developed only in *V. cinerascens* (fig. 165), *P. senegalensis* and *P. rajputanae* (fig. 173); medullary rays are found only in these members. Other members are more or less herbaceous and the structure of wood does not follow any definite lines of development, as it is found to vary in the same species.

The wood parenchyma is little developed and occurs on the inner side of the xylem bundles. The pith consists of thin-walled cells in all members except *V. cinerascens* and *P. rajputanae* where it is formed of cells with thick and lignified walls. Some of the pith cells of *P. rajputanae* contain black granular contents (fig. 173 G).

Anamolous structures are represented by small medullary xylem bundles close to the inner side of the wood cylinder of *P. rajputanae* (fig. 173 C).

SALVADORACEAE.

Salvadora persica *L.*— Figs. 191, 192, 193. Epidermis of the leaf locally two-layered. Larger veins with arcs of stone-cells on the lower side. Vascular ring more or less dumb-bell shaped. Vessels in the narrowed portion very small. Soft bast forming a continuous ring and following the outline of the wood cylinder.

Salvadora oleoides *Dcne.*— Figs. 194, 195, 196. Epidermis of the leaf uniformly two-layered. Vains with sclerenchyma on their upper and lower side. Short unicellular hairs found on branches. Wood forming a hollow cylinder of uniform breadth. Medullary rays continuous with cortical parenchyma. Soft bast forming groups.

Structure of the Leaf.— The epidermis in *S. persica* (fig. 191) is locally two-layered. The epidermal cells are tabular with outer walls thickened. The inner and lateral walls are also a little thickened and the former are convexly arched inwards. The epidermis in *S. oleoides* (fig, 194) is uniformly two-layered on both sides. The outer layer is formed of small tabular cells with the outer and lateral walls thickened; the inner layer consists of large thin-walled tabular cells with the inner walls convexly arched inwards, so as to come into close contact with the assimilatory tissue. There are a few large thick-walled ovoid epidermal cells found below the epidermis on both sides in either species; these cells probably have a water-storing function.

The stomata are associated with subsidiary cells and occur abundantly on both the surfaces. The guard-cells are situated in the plane of surrounding cells. The front cavity is usually situated in the de-

pression formed by the outer thickened epidermal walls (fig. 195); it may occasionally be found lying in a level with the surface (fig. 192).

The mesophyll (figs. 191, 194) is composed of short-celled palisade tissue on either side with an extensive tissue of vertically elongated large, thin-walled colourless cells in the middle. This middle tissue probably forms an aqueous tissue in both the species.

The veins are embedded and are enclosed in green bundle-sheaths. All the veins in *S. oleoides* have thin arcs of sclerenchyma on the upper and lower side, while only the larger veins in *S. persica* are protected on their lower side by arcs of stone-cells. There are numerous large groups of water-storage tracheids with pitted markings, occurring at intervals between the veins of both the species.

Internal secretory organs and oxalate of lime are not found.

Hairy covering is absent on the leaves of both the species. Short thick-walled unicellular clothing hairs are found on the axis of *S. oleoides* (fig. 196).

Structure of the Axis.— Epidermis consists of polygonal cells with outer walls greatly thickened and convexly arched outwards. Inner walls are thin. The stomata are like those on the leaf. Besides stomata, lenticels are found in *S. persica*. The primary cortex is composed on its outer side of chlorenchyma and on the inner side of a tissue of thin-walled colourless cells probably aqueous.

The pericycle is formed of radially elongated large groups of stone-cells separated by cortical aqueous cells. The pericycle presents a dumb-bell shaped appearance corresponding with that of the wood cylinder.

The structure of the wood is characterised by islands of soft bast (figs. 193, 196). The wood cylinder is of uniform breadth in *S. oleoides*, while in *S. persica* it is much narrowed on opposite sides in one plane, thus giving a dumb-bell shaped appearance to the whole structure. Vessels are large and have rounded lumina, except those in the narrowed portion of the wood cylinder in *S. persica*, where the vessels are very small. Medullary rays are 3-5 seriate ; and in *S. oleoides* they are continuous with cortical parenchyma between the stone-cell groups of the pericycle (fig. 196). Wood parenchyma is pretty abundantly developed on the inner side of the wood cylinder and in the neighbourhood of the islands of soft bast.

Soft bast in *S. oleoides* forms a continuous ring and follows the dumb-bell shaped outline of the wood-cylinder; in *S. persica* soft bast occurs in groups on the outer side of the xylem bundles.

The pith is composed of thin-walled cells and is characterised by numerous sieve-sclereids (fig. 193 SV).

ASCLEPIADACEAE.

Glossonema varians *Benth.*—Leaves fleshly. Epidermal cells with outer walls thickened. Guard-cells elevated. Mesophyll formed of palisade tissue on the adaxial side and of arm-palisade on the abaxial side. Cortical parenchyma extensive and formed of thin-walled colourless cells. Pericycle composed of rhomboidal groups of bast fibres with large lumina. Medullary rays uniseriate. Pith consisting of thin-walled cells with brownish contents.

Calotropis procera *Br.*—Figs. 197, 198 (*Leaf only*). Leaves fleshy. Epidermal cells with outer walls greatly thickened. Cuticle very thick. Guard-cells on the adaxial side situated quite below the plane of epidermal cells; those on the abaxial side elevated. Mesophyll consisting of extensive palisade tissue on the upper side and of extensive loose arm-palisade tissue on the lower. Clothing hairs in the form of very short uniseriate trichomes.

Pentatropis cynanchoides *Br.*—Leaves fleshly. Epidermal cells with outer walls thickened. Guard-cells elevated. Mesophyll wholly of arm-palisade tissue. Epidermis of the axis two-layered. Oxalate of lime in the form of clustered crystals in cortex and soft bast. Internal secretory cells with tanniniferous contents found in cortex and pith. Pericycle formed of long thin groups of stone-cells. Medullary rays uniseriate. Pith consisting of thin-walled cells.

Sarcostemma brevistigma *Wt.*—Fig. 199. Leafless. Epidermal cells longer than broad. Guard-cells quite below the plane of epidermal cells. Cortical parenchyma extensive and aqueous. Pericycle formed of rhomboidal groups of stone-cells. Medullary rays uniseriate. Pith consisting of thin-walled cells with granular contents.

Leptadenia spartium *Wt.*—Fig. 200. Almost leafless. Stomota in depressions formed by thickened outer epidermal walls. Mesophyll isobilateral. Clothing hairs in the form uniseriate trichomes with verrucose walls. Epidermis of the axis three-layered. Internal secretory cells with tanniniferous contents. Pericycle of rhomboidal groups of stone-cells. Vessels large on the outer side and small on the inner side. Medullary rays 1-2 seriate. Pith consisting of thin-walled cells.

Structure of the Leaf.—The epidermis is composed of small polygonal cells in all members except in *C. procera* and *P. cynanchoides* where the epidermal cells are tabular. The outer walls are thickened and convexly arched outwards. The cuticle in *C. procera* is considerably thickened (fig. 197). In *C. procera* and *L. spartium* it is superficially granulated. The epidermal cells are alike on both the surfaces except in *G. varians* and *P. cynanchoides*, where the epidermal cells on the upper side are much larger than those on the lower.

The lateral walls are thin and undulated. The inner walls are thin in all members except in *G. varians*, where they are a little thickened.

The stomata are placed in depressions produced by the thickened outer epidermal walls in *L. spartium*. In *G. varians*, *C procera* on the lower surface and *P. cynanchoides* the guard-cells are elevated and the front cavity is situated on a level with the surface. The stomata on the upper side in *C. procera* are placed in chimney-like depressions and the guard-cells are situated quite below the plane of the epidermal cells (fig. 197). Guard-cells are accompanied by subsidiary cells in all the members. The elevated position of the guard-cells is due to the fleshy character of the leaves. The depressed position of stomata in *L. spartium* and of those on the upper side in *C. procera* may be due to the poorly developed ventilating system and to the occurrence of compact palisade tissue on the upper side respectively.

The mesophyll is isobilateral in *L. spartium*, while in *P. cynanchoides* it consists wholly of arm-palisade tissue. It is composed of palisada tissue on the upper side and of arm-palisade tissue on the lower in *G. varians* and *C. procera*. In fleshy leaves the arm-palisade tissue is richly provided with a system of intercellular spaces. Chlorophyll grains are spherical and fairly large and are found along the walls of assimilatory cells.

Internal secretory organs are represented by secretory cells with tanniniferous contents near the veins in *P. cynanchoides*. The veins are few, embedded and are not provided with bundle-sheaths.

The plants are entirely or almost leafless, or have fleshy leaves. This makes the development of a hairy covering quite unnecessary, except on young leaves and axes. Clothing hairs, present on young leaves and axes, may disappear, when they are fully developed. Short uniseriate trichomes, with verrucose walls and with a large terminal cell, occur though not in great number on both the surfaces of leaves of *G. varians* and *L. spartium*. *C. procera* has short, uniseriate, depressed trichomes which are more numerous on the lower surface (fig. 198).

Structure of the Axis.— The epidermis consists of small polygonal cells with outer walls thickened and convexly arched outwards. It is two-layered in *P. cynanchoides* and is three-layered in *L. spartium* (fig. 200). The epidermal cells in *S. brevistigma* are longer than broad, thus making the epidermis quite compact and rigid. The stomata are situated in depressions produced by thickened outer epidermal walls. The guard-cells are in the plane of the surrounding cells in all members except *S. brevistigma* where they occur quite below the plane of surrounding cells, this producing a chimney-like pit above. The depressed position of guard-cells is necessary in the

axis of *S. brevistigma*, in which cortical parenchyma forms an extensive aqueous tissue.

The primary cortex is characterised by an assimilatory tissue which is formed of parenchyma except in *L. spartium* where it consists of a 4-6 cell thick arm-palisade tissue. The cortical parenchyma in *S. brevistigma* is composed of an extensive tissue of thin-walled, elongated colourless cells with probably a water-storage function and is strengthened by small scattered groups of stone-cells (fig. 199).

Secretory cells with tanniniferous contents occur in the cortex, in the broad medullary rays and in the pith of *L. spartium* (fig. 200 G.) They are also found in the cortex of *G. varians* and in the cortex, soft bast and pith of *P. cynanchoides*. Numerous clustered crystals of oxalate of lime occur in the cortex and soft bast of *P. cynanchoides*. The pericycle is composed of closely placed groups of stone-cells, except in *G. varians* in which it consists of groups of bast fibres with large lumina.

The groups of stone-cells are rhomboidal in *P. spartium* and *S. brevistigma*; they are thin and long in *P. cynanchoides*. Bast fibre groups in *G. varians* are rhomboidal.

Structure of wood can best be understood from the following tabular form.

Name of Species.	Vessels.			Interfascicular Wood Prosenchyma.		Medullary rays.		General Remarks.
	Abundance.	Size.	Arrangement.	Abundance.	Size.	Abundance.	Size.	
G. varians ...	Few ...	Large.	In rows in the inner portion.	Not extensive.	Large lumen.	Few ...	1-Seriate.	Wood modified by the direction of the wind. Broader in the plane affected by wind.
P. cynanchoides..	,,	,,	,,	,,	Small lumen.	,, ...	,,	Vessels large and few in the outer portion, small and numerous in the inner portion.
S. brevistigma ...	Numerous.	Small.	In complete rows.	,,	,,	Numerous.	,,	Vessels in complete rows.
L. spartium ...	Few ...	Large.	In rows in the inner portion.	,,	,,	Few ...	1-2 Seriate.	As in G. varians.

The peculiar isobilateral structure of the wood of *G. varians* is due to the fact that portions of the axis with greater development of wood represent the plane affected by the prevailing wind and possessing greater functional activity; the two opposite sides of the axis with poorly developed wood represent the plane less affected by the prevailing wind and have no necessity of developing an extensive water-conducting or strengthening tissue. The plane with well developed wood represents the direction of the prevailing wind. The wood parenchyma is not extensive and is found on the inner side of the wood ring.

The soft bast is very extensive in *P. cynanchoides*.

The pith consists of thin-walled cells. Some of the pith cells of *S. brevistigma* contain spherical granular bodies.

General Review.—The epidermal cells have the outer walls greatly thickened. The guard-cells are situated in the same plane or quite below the plane of the surrounding cells. The stomata are accompanied by subsidiary cells. The ventilating system is fairly extensive. Secretory cells with tanniniferous contents are found in some members. Oxalate of lime is found in the form of small clustered crystals in *P. cynanchoides*. Hairs, when present occur in the form of short uniseriate trichomes. Cortical parenchyma is extensive. The pericycle is either composed of groups of stone-cells or of bast fibres. The wood forms a composite hollow cylinder. Perforations of the vessels are simple. The wood prosenchyma is composed of cells with thick walls and with small lumina. The medullary rays are 1—3 seriate. Pith consists of thin-walled cells.

GENTIANACEAE

Enicostemma litorale *Bl.*—Fig. 201. Epidermal cells with outer walls very greatly thickened and with inner walls convexly arched inwards. Lateral walls thin and undulated. Stomata on both the surfaces elevated Mesophyll wholly of chlorenchyma. Internal glands absent. Oxalate of lime in the form of star-like clusters of acicular crystals. Leaves many-ribbed. Veins of ribs vertically transcurrent. Vascular bundles in leaf and axis bicollateral. Axis irregularly ribbed. Scleranchymatous pericycle absent. Cortex formed of chlorenchyma. Wood composite with an outer and inner ring of soft bast. Vessels in numerous complete rows. Medullary rays uniseriate. Pith of thin-walled cells.

Structure of the Leaf.—The epidermis consists of polygonal cells with outer walls very greatly thickened (fig. 201). The lateral walls are thin and undulated. The inner walls are thin. The cuticle is

striated. The epidermal cells at the margin have outer walls convexly arched outwards and have both the inner and outer walls thickened. The margins are strengthened by a few collenchymatous cells. The stomata occur abundantly on both the surfaces and are surrounded by ordinary epidermal cells. The guard-cells are elevated and the front cavity is on a level with the surface. The mesophyll is formed of a homogeneous tissue of horizontally elongated polygonal assimilatory cells. Internal secretory organs are found neither in the leaf nor in the axis.

The leaves are many-ribbed and the veins of the ribs are vertically transcurrent above and below by collenchyma. The smaller veins are embedded. The vascular bundles of the veins are bicollateral.

Clothing as well as glandular hairs do not occur on the leaf and axis.

Structure of the Axis.—The axis is irregularly ribbed, some of the ribs being wing-like. The ribs are strengthened by collenchyma. The epidermis consists of tabular cells with both outer and inner walls thickened. The cuticle is striated. The cortex is composed of chlorenchyma which extends to the ribs.

A sclerenchymatous pericycle is not developed. The wood is composite and is broader below the ribs. The vessels are small and are arranged almost in complete rows. Interfascicular wood prosenchyma is little developed. The medullary rays are uniseriate and numerous. The vascular bundles are bicollateral and have two continuous rings of soft bast—one on the outer and another on the inner side of the wood cylinder. The pith is composed of thin-walled cells.

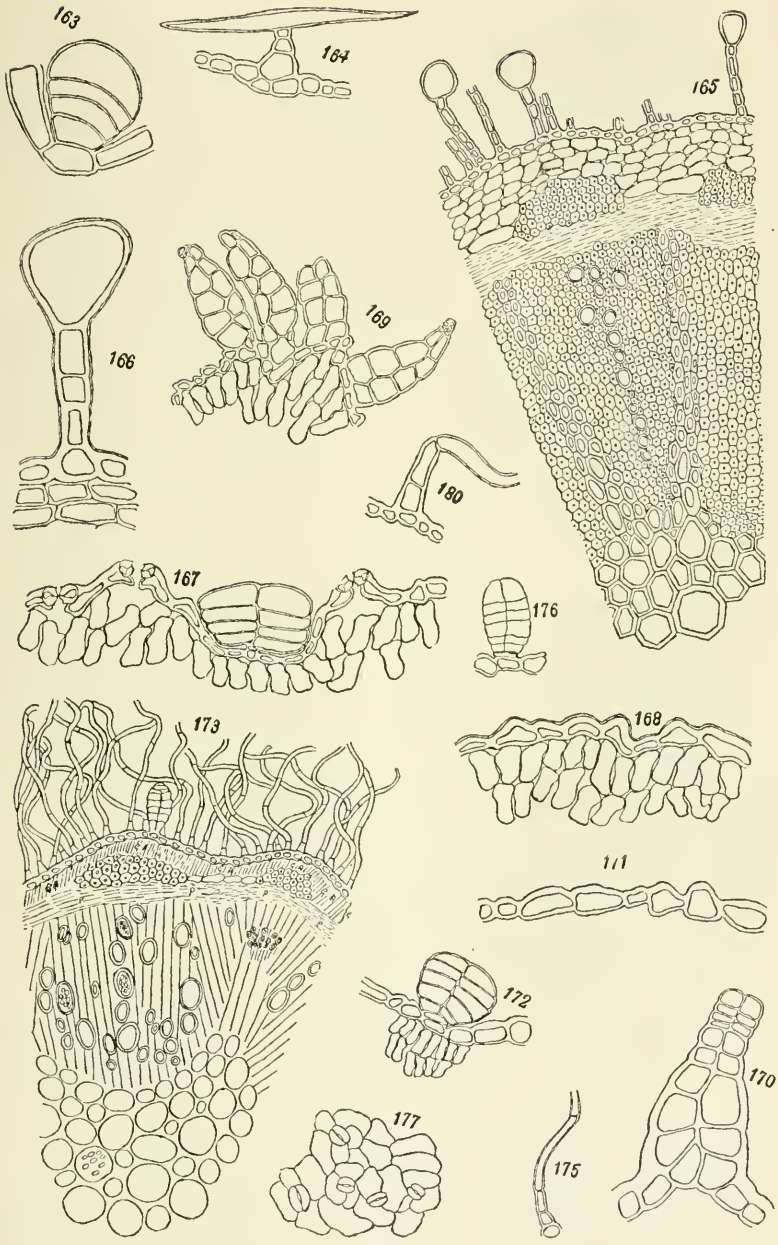
Oxalate of lime occurs in the form of star-like clusters of acicular crystals in cortical parenchyma and pith.

(*To be continued.*)

Plate XIX

163-166. *Vernonia cinerascens.*
163. Glandular hair on the leaf.
Oc. 6 Com.; Ob. 3 mm. Ap.
164. Hair on the leaf.
Oc. 6 Com.; Ob. 8 mm. Ap.
165. T. S. of the axis.
Oc. 6 Com.; Ob. 8 mm. Ap.
166. Glandular hair on the leaf.
Oc. 6 Com.; Ob. 3 mm. Ap.
167-170. *Pegolettia senegalensis.*
167. T. S. of the leaf showing stomata and a glandular hair.
Oc. 4 Com.; Ob. 3 mm. Ap.
168. T. S. of the leaf showing the epidermis.
Oc. 4 Com.: Ob. 3 mm. Ap.
169. T. S of the leaf showing the lower portion of the mid-rib bearing glandular hair.
Oc. 4 Com.; Ob. 8 mm. Ap.
170. Glandular hair on the axis.
Oc. 4 Com.; Ob. 3 mm. Ap.
171-172. *Pulicaria angustifolia.*
171. T. S. of the leaf showing the epidermis.
Oc. 4 Com.; Ob. 3 mm. Ap.
172. Glandular hair on the leaf.
Oc. 4 Com.; Ob. 3 mm. Ap.
173-177. *Pulicaria rajputanae.*
173. T. S. of the axis.
Oc. 6 Com.; Ob. 8 mm. Ap.
175. Hair on the leaf.
Oc. 6 Com.; Ob. 8 mm. Ap.
176. Glandular hair on the leaf.
Oc. 4 Com.; Ob. 3 mm. Ap.
177. Stomata in surface view.
Oc. 4 Com.; Ob. 3 mm. Ap.
180. *Echinops echinatus.*
Hair on the axis.
Oc. 4 Com.; Ob. 3 mm. Ap.

N.B.—To get the original dimensions multiply by 1·7.



T. S. Sabnis del. PLATE XIX.

Plate XX

174. *Pulicaria rajputanae.*
T. S. of the leaf.
Oc. 6 Com.; Ob. 8 mm. Ap.

178-179. *Eclipta erecta.*
178. T. S. of the axis showing epidermis and collenchyma.
Oc. 4 Com.; Ob. 3 mm. Ap.
179. Glandular hair on the leaf.
Oc. 4 Com.; Ob. 3 mm. Ap.

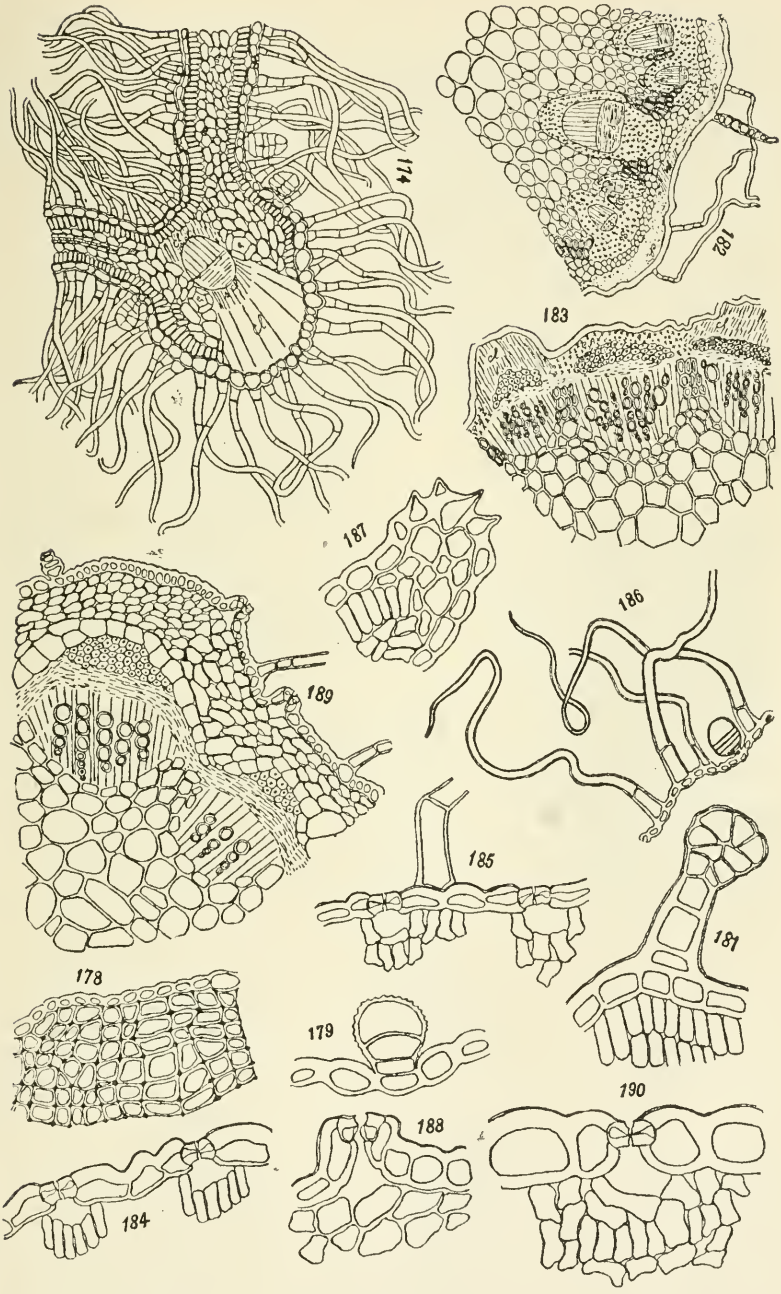
181-182. *Echinops echinatus.*
181. Glandular hairs on the leaf.
Oc. 4 Com.; Ob. 3 mm. Ap.
182. T. S of the axis.
Oc. 2 Com.; Ob. 8 mm. Ap.

183. *Volutarella divaricata.*
T. S. of the axis.
Oc. 2 Com.; Ob. 8 mm. Ap.

184-189. *Dicoma tomentosa.*
184. T. S. of the leaf showing the upper epidermis and stomata.
Oc. 6 Com.; Ob. 3 mm. Ap.
185. T. S. of the leaf showing the lower epidermis.
Oc. 6 Com.; Ob. 3 mm. Ap.
186. T. S. of the leaf showing the lower epidermis and hairs.
Oc. 6 Com.; Ob. 8 mm. Ap.
187. T. S. of the leaf near the margin.
Oc. 4 Com.; Ob. 8 mm. Ap.
188. Stomata on the axis.
Oc. 6 Com.; Ob. 3 mm. Ap.
189. T. S. of the axis.
Oc. 6 Com.; Ob. 8 mm. Ap.

190. *Launaea chondrilloides.*
Stoma on the leaf.
Oc. 6 Com.; Ob. 3 mm. Ap.

N.B.—To get the original dimensions multiply by 1·7.

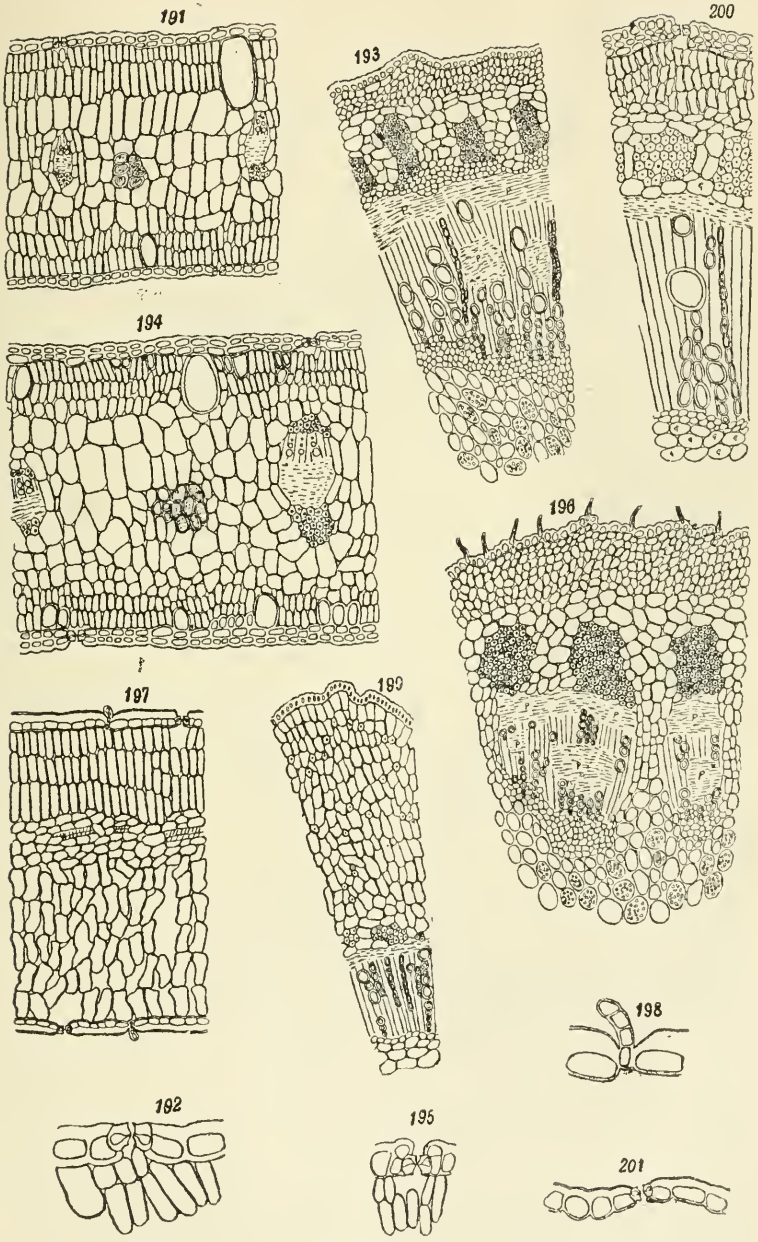


T. S. Sabnis del. PLATE XX.

Plate XXI

191-193. *Salvadora persica.*
191. T. S. of the leaf.
Oc. 4 Com.; Ob. 8mm. Ap.
192. Stoma on the leaf.
Oc. 6 Com.; Ob. 3 mm. Ap.
193. T. S. of the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.
194-196. *Salvadora oleoides.*
194. T. S. of the leaf.
Oc. 4 Com,; Ob. 8 mm. Ap.
195. Stoma on the leaf.
Oc. 4 Com.; Ob. 3 mm. Ap.
196. T. S. of the axis.
Oc. 4 Com.: Ob. 8 mm. Ap.
197-198. *Calotropis procera.*
197. T. S. of the leaf.
Oc. 4 Com.; Ob. 8 mm. Ap.
198. Hair on the leaf.
Oc. 6 Com.; Ob. 3 mm. Ap.
199. *Sarcostemma brevistigma.*
T. S. of the axis.
Oc. 2 Com.; Ob, 3 mm. Ap.
200. *Leptadenia spartium.*
T. S. of the axis.
Oc. 6 Com.; Ob. 8 mm. Ap.
201. *Enicostemma litorale.*
T. S. of the leaf showing the epidermis.
Oc. 6 Com.; Ob. 8 mm. Ap,

N.B.—To get the original dimensions multiply by 1·7.



T. S. Sabnis del. PLATE XXI.



FROM THE JOURNAL OF THE GEOGRAPHICAL SOCIETY

THE DISTRIBUTION OF FLORAS IN S. E. ASIA AS AFFECTED BY THE BURMA-YUNNAN RANGES.

By Capt. F. Kingdom Ward, B.A., F.R.G.S.

I propose first to give a brief account of the flora of the N. E. Frontier of Burma, secondly to indicate its relationships, and thirdly to point out the significance of the N. E. Frontier ranges as regards geographical distribution in S. E. Asia generally.

The N. E. Frontier is formed by a broad arc of very mountainous country sweeping round in a half circle from the eastern end of the Himalaya. Here it forms the watershed between the Brahmaputra and Salween drainage systems. Turning south, it forms the watershed between the Irrawaddy, rising within the curve, and the Salween. My remarks on the flora refer especially to this southern part (Lat. 26° N. Long. 98° 30′ E.)

The whole region up to an altitude of 12,000 feet is covered with forest, which is divisible into (i) jungle up to 5,000 feet (ii) temperate rain forest 5,000—8,000 feet (iii) Conifer forest above 8,000 feet.

The jungle is made up entirely of Indo-Malayan forms. It contains species of *Dipterocarpus*, *Shorea*, *Hiptage*, *Elaeocarpus*, *Engelhardtia*, *Garcinia*, *Caryota*, *Calamus* and *Ficus*; many lianas, such as *Mussaenda*; climbing *Aroids*, like *Raphidophora* and *Pothos*; tree ferns; and in the undergrowth many *Zingiberaceae*, *Acanthaceae* and *Gesneraceae*. There are also many epiphytic ferns and orchids.

The temperate rain forest contains many big trees which rarely possess feebly developed plank buttress roots. Characteristic genera are *Schima*, *Gordonia*, *Bucklandia*, *Quercus*, *Magnolia*, *Acer*, *Rhododendron*; also several palm-like *Araliaceae*, and occasional species of *Ficus*. Most of the trees are loaded with epiphytic ferns, orchids and *Aeschynanthus*; and there is a striking development of moss. There are a few lianas of temperate genera—*Clematis*, *Hydrangea*, *Aristolochia*. Undergrowth is not very dense except in deep gullies, it is chiefly bamboo. Small herbs abound, especially *Urticaceae*, *Impatiens*, and *Strobilanthes*.

In the Conifer forest there is a preponderance of *Abies*, bamboo and *Rhododendron emuldrum*. Other Conifers, such as the Chinese coffin plank tree (*Juniperus* sp). and a larch are curiously local; more widely distributed is a *Pseudotsuga*. I must also mention here a pine,

though it does not belong to this belt, being found on rocky grass-clad slopes between 4000 and 7000 feet; nor does it form forests, growing with oak and alder trees in open park land.

There are also a large number of shrubs in the Conifer forest—species of *Rhododendron*, *Euonymus*, *Ribes*, *Rubus*, *Picris*, *Echinanthus*, *Rosa*, *Philadelphus*, *Deutzia*, *Hydrangea*, *Buddleia*, and others; and a few climbers, including *Schizandra*, *Akebia*, and *Smilax*.

In some places, between 9000 and 11000 feet, especially where it is marshy, alpine meadow is developed. Here grow species of *Nomocharis*, *Thalictrum*, *Epipactis*, *Allium*, *Lilium*. *Meconopsis*, many *Compositae*, *Umbelliferae*, etc.

Finally, in the alpine belt are many dwarf *Rhododendrons*, and shrubs such as *Potentilla fruticosa*, species of *Spiraea*, *Pyrus*, *Berberis*, and bamboo. On the screes and rocks species of *Primula*, *Cremanthodium*, *Lloydia*, *Pedicularis*, *Saxifraga*, *Gentiana*, *Cassiope*, *Androsace*, abound; and there are a few cushion plants.

The most extensively represented order in the mountain belt is *Ericaceae*. Not only are there over fifty species of *Rhododendron* alone, but many of them grow socially, covering the summits of the mountains as heather on a Scotch moor. Other well represented genera are *Impatiens*, *Begonia* and *Strobilanthes* at low altitudes; *Rubus*, *Polygonum*, *Primula* at intermediate altitudes; *Pedicularis*, at high altitudes.

But it would give a wrong impression of the flora, did I not mention orders and genera so wealthy in species as *Orchidaceae*, *Gesneraceae*, *Leguminosae*, *Acanthaceae*, *Zingiberaceae*, *Ranunculaceae* *Liliaceae*, *Saxifragaceae*, *Rosaceae*, *Araliaceae*, with *Arisaema*, *Chirita*, *Euonymus* and *Aeschynanthus*.

I now pass on to the question of relationship.

The North East Frontier ranges lie on the flank of the Yunnan plateau to the east, and may be regarded as forming a huge bluff overlooking the low country of Burma and Assam.

Critical examination of the flora shows a mixture of Himalayan, Indo-Malayan, Chinese and endemic forms.

The preponderance of an Indo-Malayan flora at low altitudes is easily understood, since these ranges penetrate the Indo-Malayan region to the south and west. The point to notice is that it is soon lost; it does not extend eastwards. In the Brahmaputra valley, the Indo-Malayan flora gets as far as 30° N. in the Irrawaddy basin to about 29°, in the next valley to the east—the Salween, to about 28°, but so impoverished as to appear scarcely dominant. In the Mekong valley however it only penetrates to about the twenty-third parallel, i.e., to the tropic, and now it is sadly stricken.

Eastwards of the Mekong this Indo-Malayan flora spreads over the peninsulas of S. E. Asia, south of the tropic, and creeps northwards up the China coast again almost as far as the Yangtze in latitude 30,° but only as a narrow belt. However, there is a wide divergence between the Indo-Malayan flora of Fokien and that of the Irrawaddy basin in the same latitude, owing to the N. E. Frontier barrier and the intervening plateau of Yunnan, which has prevented any transference of species across from west to east.

The Himalayan element is very strongly represented at intermediate altitudes, less so in the alpine region, though the connection is well seen there too.

Now this flora cannot have made its way straight across the Assam and Irrawaddy valleys from the broken end of the Himalaya. It must have come right round the arc from the north; and we naturally ask: How did it cross the gorge of the Dihang, which even now separates the eastern Himalaya from the N. E. Frontier belt?

How can the seeds of alpines and sub-alpines, which are rarely constructed for long distance travel, cross such a chasm? I need only instance such plants as *Meconopsis Wallichii*, *Isopyrum adiantifolium* and *Lilium Thompsonianum*. Such plants as actually have seeds adapted to long distance travel, e.g. *Podophyllum Emodi*, *Lilium giganteum* and *Rosa sericea*, are found much further east than the N. E. Frontier ranges, extending into Kauru, Sheuri, and often right across China to Japan.

Two possible explanations suggest themselves to account for this strong Himalayan element on the N. E. Frontier.

(i) That the whole region of southern and eastern Tibet enjoyed originally a temperate climate, and was covered by a uniform flora. When desert conditions began to prevail in Tibet, owing to the uplift, in Eocene times, of the Himalaya, and the N. E. Frontier ranges, the flora withdrew to these mountains, and was subsequently separated into three great blocks—Himalaya, N. E. Frontier, and western China—by the formation of the river gorges. This theory requires the flora to be of Pre-eocene age, but that is not impossible.

(ii) That there was previously a continuous Sino-Himalayan range, as it may be called, stretching across the present headwaters of the Irrawady and binding the Himalaya to the great China divide which passes through Kauru and Sheuri; and that this range was breached by the uplift of the N. E. Frontier ranges since Eocene times. But there is no proof at present that the N. E. Frontier ranges are younger than the Himalaya uplift though they certainly are features of original structure, and not, as Kropatkin believed, ridges separating grooves cut in the Tibetan plateau by the rivers,

In other words, the breach in the Sino-Himalayan range is not the passive work of rivers cutting their way back, but is a far more formidable gap resulting from an active uplift of ranges whose axes cut across a possibly older uplift.

But whether we hold that this Sino-Himalayan flora was once more widely spread over Tibet at a time when that country had a more genial climate, as suggested in the first alternative; or whether we hold that it merely crept across from Kauru to the Himalaya along a continuous range, prior to the uplift of the N.E. Frontier ranges, subsequently surging southwards through the breach they made, as in the second alternative; we perceive that many species, now quite isolated, have survived unchanged through a long period, since they are now found in places as far apart as the Himalaya, N.E. Frontier and western China, to say nothing of Japan and N. America.

I say nothing as to the direction taken by the stream of flora, beyond the manifest fact that the alpine flora of the Htawgaw Hills (Lat. 26° N., Long. 98° 30 E.) has come neither from the east, nor from the west, but straight down the ranges from the north.

No doubt the flora of the great Asiatic divide has swayed backwards and forwards, but in the main it is generally believed to have originated within the Arctic circle, and to have moved southwestwards into Asia and south-eastwards down the Atlantic coast of N. America, with the glaciation of the North. So much for its introduction into Asia; but its movements after that are another matter, altogether. That hypothesis sufficiently accounts, in a broad way, for the relationship existing between the floras of the Himalaya, Japan and North America; it by no means accounts for the relationship existing between the floras of the N. E. Frontier, the Himalaya, and Western China.

The Chinese element in the flora is also conspicuous, but a distinction must here be made between the two sources from which it has been derived. These are :—

(i) The valleys to the immediate south and east; (ii) the high ranges of far western China, which, thrusting southwards from the main body hold in their grasp much of Yunnan. These sources must be carefully distinguished.

As regards the first, this flora extends eastwards no further than the Salween valley, and northwards no further than about the 26th parallel; that is, it embraces the basin of the Shiveli river. It may be called the Burma-Yunnan area, and is characterised by many identical species of *Rhododendron*, by the *Candelabra Primulas*, many *Celastraceae*, *Gesneraceae*, etc. This flora is highly endemic. The typical Chinese flora is confined to higher altitudes, and includes

many alpines such as *Polygonum Forsterii*, *Primula serratifolia*, *Cassiope palpebrata*, besides sub-alpines such as *Primula sonchifolia*, *Nomocharis*, etc.

But with the flora of Yunnan east of the Salween, apart from the high ranges which thrust long processes southwards from the northern mountain masses, the North East Frontier flora seems to have nothing in common.

Endemic species are found especially in the alpine region, and to a lesser extent at intermediate altitudes. Amongst the former may be mentioned species of *Rhododendron*, *Primula*, *Cremanthodium* etc., amongst the latter the monotypic genera *Beesia* and *Sporoxia*, species of *Strobilanthes*, *Codonopsis* and various *Gesnerads*.

Those plants which are both Himalayan and Chinese are widely distributed across eastern Asia, often occurring in Japan as well and sometimes even in N. America. (e.g., *Clitoria mariana*). On the other hand there are plants ranging from the Himalaya into western China, which are not found on the N. E. Frontier, (e.g., *Isopyrum grandiflorum*).

Plants from what I have called the Burma-Yunnan area are not found in the Himalaya. This area is simply the splayed out ends of the North East Frontier belt, tailing off southwards into the Indo-Malayan region; it has carried this flora southwards into the Indies, where for instance *Primula imperialis* is found on the mountains of Java.

But many plants of the Himalayan foot hills, representing the Indo-Malayan element, are found in the Burma-Yunnan area.

Negative results in the alpine belt are as valuable as positive results. I have insisted on the relationship of the alpine flora to that of the Himalaya and western China; but what shall we say to the complete absence of such typical genera as *Aquilegia*, *Incarvillea*, *Primulas* of the *Amethystina* section, and *Pinguicula alpina*; and to the extreme poverty of such as *Meconopsis*, woolly *Compositae*, alpine *Leguminosae*, *Berberis*, *Cotoneaster*, *Lonicera*, etc.? In view of the large number of *Rhododendrons*, especially of the dwarf groups, we are, forced to the conclusion that if it is simply a question of altitude—and the highest peaks are little over 13,000 feet— then altitude affects plants both absolutely and relatively. In other words, *Rhodadendrons* flourish within 1,000 feet of the snow line, wherever the snow line may be; but *Meconopsis* for instance, flourishes only above 15,000 feet.

We are now in a position to appreciate to some extent the part played by the North East Frontier belt as regards distribution in South East Asia generally.

In the main it clearly separates the Indo-Malayan flora from the Chinese flora. But at the southern end of the belt, there is an interpolated flora,— endemic to a high degree, but related also to the Indo-Malayan on the one hand, and the Yunnan plateau on the other — occupying the Burma-Yunnan area.

Striking, however, as is this North East Frontier belt as a barrier, it is even more so as a bridge between the Himalayan ranges to the west and the Chinese ranges to the east. Despite their complete separation, the two former areas possess closely related floras.

There has been something of a volt face as regards the Himalayan and Chinese floras. Formerly they were believed to be almost identical. Exploration in western China showed that this was not the case, and lately the tendency has been to exaggerate the differences, which after all turn largely on our conception of species. The North East Frontier belt is the link between the two, and their relationship will be better appreciated as the flora of the former is investigated.

The three areas, Himalaya, North East Frontier and western China form a sort of letter Y, the three limbs of which, each composed of parallel ranges, are separated from one another, but connected independently with the desert plateaux of central Asia; and it will probably be found that while the easternmost range of the N.E. Frontier belt shows a closer relationship with the western China limb, the westernmost range shows a closer relationship with the Himalayan limb.

If our conception of a Sino-Himalayan range, subsequently breached, is correct, then clearly a Sino-Himalayan flora reached from Nepal to Sheuri before it appeared on the N.E. Frontier ranges to the South. The subsequent uplift of these ranges, breaching the Sino-Himalayan range, would account for the presence of both Himalayan and north-west China plants so far south, derived from the broken ends of the main range.

To sum up, the N. E. Frontier belt, and more especially the Mekong-Salween divide, is primarily a barrier, botanical and zoological, marking the eastern limit of the Indo-Malayan, or Oriental region, for at least 750 miles.

Secondarily it is, or has been, connected in the north with the Himalayan ranges on the one hand, and with the great China divide on the other, serving both to keep them apart and to link them up to a common centre.

DROUGHT RESISTING PLANTS IN THE DECCAN.

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The drought of 1918-19 in the Bombay Deccan was one of the most long-continued and severe on record. While the normal rainfall over most of the area lies between 20 and 30 inches per annum—though it is much higher than this in the west—the actual rainfall for 1918 was in most cases between one third and one half of this amount, and of the quantity received a very considerable proportion was received in one or two fitful storms in May and August or September 1918. The actual condition of things in five typical centres, given in order from west to east is shown in the following table :—

	Vadgaon	Poona	Sirur	Ahmed-nagar	Shevgaon
	ins.	ins.	ins.	ins.	ins.
Average Annual Rainfall ...	41·90	29·19	20·30	23·29	25·77
Rainfall in 1918	17·51	14·58	9·78	14·57	9·31
Rainfall in January, 1918 ...	0·17	0·15	...	1·45	0·04
„ February, 1918 ...	...	...	...	...	...
„ March, 1918 ...	...	0·12	...	0·05	...
„ April, 1918 ..	...	...	...	...	..
„ May, 1918	4·15	4·70	3·72	5·32	2·45
„ June, 1918	0·71	0·31	1·76	1·52	0·37
„ July, 1918	2·97	1·02	1·41	0·71	0·47
„ August, 1918 ...	9·20	2·30	0·37	0·47	1·35
„ September, 1918 ...	0·25	3·01	1 85	4·15	3·31
„ October, 1918 ...	...	1·74	0·41	0·78	...
„ November, 1918 ...	0·06	1·11	0·03	0·03	0·21
„ December, 1918 ...	...	0·12	0·23	0·10	1·11
„ January, 1919 ...	...	...	0·05	0·29	0·01
„ February, 1919 ...	...	...	...	0·21	0·47
„ March, 1919 ...	...	0·32	0·10	0·07	...
„ April, 1919 ...	...	...	...	0·05	...
„ May, 1919	1·97	3·89	1·15	0·57	0 25

The result of this long-continued drought was that in 1918 the usual wild monsoon plants did not grow well, or if they grew at all most of them died before seeding or seeded before they were half grown. The country never looked green, and, except for the trees which remained green, was a desert-like waste in the latter part of 1918 and the earlier part of 1919. Even the most resistant plants suffered. In

some places it was reported that Babul trees (*Acacia arabica* Willd.) had died. As a matter of fact many of the Banian trees (*Ficus bengalensis* L) especially those which happened to be growing on road sides near dry hills showed an unusual leaf-fall and remained practically bare of leaves for some time. Even the very resistant prickly pear (*Opuntia nigricans* Haw.) showed signs of suffering, and in April 1919 had taken on a yellow colour and was drooping over extensive areas.

It seemed a matter of some interest under these very exceptional conditions to ascertain what plants remained actually alive and growing, and to find the amount of available moisture round the roots of such plants. The enquiry did not concern itself with trees, but only with herbaceous and sub-woody plants, and particular attention was devoted to (1) finding out to what degree the moisture conditions can be reduced, without preventing the wild indigenous weeds, mostly of arable land, from living and growing (2) *noting the general behaviour of the plants or the particular adaptation of the different plant-organs which seemed to enable the plants to tide over the drought, and (3) making special notes of any plants of agricultural or other economic value (especially of fodder value) that lived and grew through the drought, so that they might be tried as additions to the drought resisting plants actually grown in the country. This last aspect of the study was considered to be of very great importance, for shortness of fodder is now the great characteristic of famines in the Deccan.

A chain of stations was made across the Deccan, and working from these all the plants, whether likely to be of use or no, which were living and growing at the hottest and driest part of 1919 in the month of May were secured, and in many cases samples of the soil in which they were growing were collected for a moisture determination. The samples of soil were taken, chiefly from the lower one third of the root region.

Moisture determination in the soil thus collected gave some difficulty. It was obvious that a mere determination of the loss on heating in a steam bath would not give the actual amount of "free" water in the soil,—and it is the "free" water that it was important to

* In doing this a comparison of the herbarium material of the different species collected from time to time in different situations as regards rainfall and soil, conditions was made, with the plants now collected to see what deviations from the normal type could be detected in each case. And although we cannot rely solely upon such a comparison in determining the behaviour of a plant in a particular situation under different conditions of soil moisture still in the absence of any direct comparison, that was the only course left open.

estimate. To get as close as possible to an idea of the actually available water for the plants, the soil was dried at 45 to 50° c. on a sand bath till the weight was constant.

The survey, as already stated, was made in May 1919. It must be pointed out, however, that before the observations and notes were completed, there had been slight rain in a few places. But this rain rarely amounted to more than a few hundredths of an inch.

The principal plants found living and growing under the conditions of extreme drought described are shown in the following list:—

1. **Polygonum plebejum** *R. Br.*—This was found on medium black sticky soil at Talegaon * on May 1, 1919. The available moisture round the roots was about 3,00 per cent.

An examination of the herbarium material of the species shows that under different rainfall or soil conditions the species varies a great deal as regards the size of the plant, the length of the internodes, and the size of the leaves.

As collected now it was a very small prostrate or diffuse plant scarcely half an inch above the ground, branched from near the base, branches barely reaching an inch in length. The root was slender, $\frac{1}{12}$ inch in diameter, and 3—4 inches in length. It had no lateral branches. The leaves were very minute, scarcely $\frac{1}{8}$ inch in diameter. The plant was in flower and showed some purple anthocyanin pigment.

Reduction of the size of the plant and of the leaves to about $\frac{1}{6}$-$\frac{1}{8}$ of the well developed size is therefore the only response of the plant in the present abnormal conditions.

2. **Chrozophora prostrata** *Dalz.*—Rather common. This was found on medium black, sticky soil at Talegaon, on May 1, 1919. The available moisture round the roots was about 3'00 per cent.

This plant also seems to vary much in different places, as regards the length of the branches and the size of leaves.

As collected now it was a small prostrate plant, scarcely an inch above the ground. The root was slender, $\frac{1}{10}$ inch in diameter and 5—6 inches in length, devoid of lateral branches. Branches of the stem were 1—2 inches long, and leaves stellately hairy. The leaves were $\frac{1}{6}$—$\frac{1}{4}$ inch long and broad. The plant was in fruit. It had also developed some anthocyanin pigment in the stem and leaves.

Thus reduction in size is apparently the only response of the plant in the present conditions.

3. **Solanum xanthocarpum** *Schl.*—Rather common. It was found on medium black soil which was somewhat more sticky

* The rainfall of Talegaon is closely similar to that shown above for Vadgaon.

than in the case of Nos. 1 and 2 at Talegaon, on May 1, 1919. The available moisture round the roots was about 3·50 per cent.

In different situations the plant shows slight variation as regards the size of the leaves and their prickliness.

In the present instance it showed practically no deviation from the average plant. It had a tap root 9—10 inches long and $\frac{1}{4}$ inch in diameter.

4. **Argemone mexicana** *L.*—Rather common. This spiny leafed plant was found under similar conditions to No. 3 at Talegaon on May 1, 1919. Available moisture round the roots was about 3·50 per cent.

Except for the size, the plant shows no appreciable difference in different situations.

In the present instance also it did not show any deviation from the normal type. The root was a tap root about 9—10 inches long and $\frac{1}{3}$—$\frac{1}{2}$ inch in diameter, divided in the lower half into two slender branches about $\frac{1}{5}$—$\frac{1}{8}$ inch in diameter.

At Talegaon and on the same day as the above plants were examined, the following plants were also noticed occupying a rugged place; no samples of soil were however taken in their case:—

Euphorbia neriifolia *Linn.*—Several plants showing a sickly yellow colour and no leaves.

Bombax malabaricum *DC.*—In a leafless condition.

Opuntia nigricans *Haw.*—Several plants with a yellowish colour and thin flaccid looking phylloclades.

Gymnosporia Rothiana *Laws.*—In a practically leafless condition.

Flueggia leucopyrus *Willd.*—In a practically leafless condition.

Lantana indica *Roxb.*—In a practically leafless condition.

Vitis Woodrowii *Stapf.*—In a leafless condition, but the young leafbuds were just sprouting.

Acacia arabica *Willd.*—Practically in the normal condition.

It may be noted that all these plants are perennial and with the exception of the Acacia and Opuntia (in which latter the leaves are absent) loss of leaves was their chief device for tiding over the drought.

5. **Lepidagathis trinervis** *Nees.*—var. **asperrima** ?—Rather common in the place. It was found in a light grey coarse soil (murum) with a layer of dust above, in an open barren situation, at Belapur* on May 6, 1919. The soil round the roots contained 1·28 per cent. of available moisture.

* The rainfall here is not unlike that at Ahmednagar or at Shevgaon above recorded.

The species seems to vary much as regards the size of the plant or its leafiness. It also shows some variation as regards having two kinds of roots, viz. fibrous roots in addition to the tap root in various situations, (possibly this is also true in the case of several other plants mentioned in this list, though perhaps to a less extent than in the present case).

As collected here the plant had a diffuse woody stem covered with very small cuspidate leafy bracts provided with rough hairs. The tap root was woody, about 6—8 inches long and $\frac{1}{4}$ inch in diameter with numerous fine rootlets or feeding roots near the surface of the soil where they came in contact with the dust. The plant was in fruit.

In the present instance the practical absence of leaves, presence of numerous feeding roots in addition to the woody tap root and the possession of hairs on the minute leafy organs (reduced bracts ?) seems to be the plant's response to the drought conditions.

6. **Tephrosia purpurea** *Pers.*— The plant is common in the tract. It was found in light grey coarse soil (murum) in an open barren situation, at Belapur, on May 6, 1919. The soil round the roots contained 1·38 per cent. of available moisture.

The species varies to some extent as regards the size of the plant, the size and number of leaflets, and the hairiness of the plant in different situations.

In the present instance reduced size and some suppression of the leaflets seems to be the only response of the plant. The root of the plant was a tap root 8—9 inches long, about $\frac{1}{2}$ inch in diameter, with several small lateral branches.

7. **Zizyphus xylopyra** *Willd.*—This prickly plant is very common in the tract. It was found at Belapur on May 6, 1919 on light grey poor soil in an uncultivable place. The soil round the roots contained 1·89 per cent. of available moisture.

It varies a great deal as regards the size of the plant and of the leaves according to situation. In favourable situations it grows into a tree.

In the present instance the plant was scarcely three feet high and had very small leaves about $\frac{1}{2}$—$\frac{2}{3}$ inch in diameter. It was much branched from near the base. It had a long tap root $\frac{2}{3}$ inch in diameter with several laterals which spread somewhat horizontally.

A mere reduction in size was therefore the response though not necessarily an unusual response of this plant. Often in ordinary times also the species does not assume larger dimensions in this tract.

8. **Tragia cannabina** *L.*—This occurred at Belapur on May 6, 1919, in deep black very sticky soil, which round the roots of this plant contained 3.36 per cent. of available moisture.

The plant varies a good deal as regards the size of the leaves and their hairiness.

As collected here the plant was about 6—8 inches in height. It was thickly covered with stiff and stinging hairs. The root stock was thick about $\frac{2}{3}$ inch in diameter, soon divided into several rather stout lateral root-branches about 1—2 feet long and spreading obliquely. The leaves were tripartite to the base with narrow and divided lobes which were about an inch long and $\frac{1}{5}$ inch broad. The plant was not in flower or fruit.

Thus the hairiness of the leaves had increased and their size was reduced to at least $\frac{1}{2}$—$\frac{1}{3}$ the size to be found in favourably placed plants.

9. **Echinops echinatus** *Roxb.*—This prickly plant with cottony under surface of the leaf is very common in the tract. It was found on light grey coarse soil (murum) on uncultivable land. The soil round the roots contained 1.55 per cent. of available moisture.

The plant only shows some little variation as regards the size it attains in different situations, and in the present instance it only showed a slight reduction in the same. Its root was a tap root 6—8 inches long and $\frac{1}{6}$ inch in diameter devoid of lateral branches.

10. **Leptadenia reticulata** *W. & A.*—This was found in medium black or brownish soil of rather sticky character, at Belapur, on May 7, 1919. The soil round the roots contained 2.33 per cent. of available moisture.

The plant varies a great deal as regards the size of the leaves in various situations. The leaves have accordingly become very small in the present instance. They only attained $\frac{3}{4}$—1 by $\frac{1}{6}$—$\frac{1}{3}$ inch. The plant was peculiar in having a root about 10 feet long and $\frac{1}{2}$—$\frac{2}{3}$ inch in diameter. The root stock was about an inch and a half in diameter and gave rise to several branches of the stem. The root spread horizontally about six inches below the surface of the soil and had a few long and slender branches. The old root and the old part of the stem had a rough and deeply cracked corky bark. The leaves of this plant are used as a vegetable in times of scarcity by the poorer people.

11. **Cucumis trigonus** *Roxb.*—This was found in medium black, sticky soil at Belapur, on May 7, 1919. The soil round the roots contained 2·59 per cent. of moisture.

The plant seems to vary much as regards the length of the branches and the size, division and hairiness of the leaves, in different situations.

In the present instance also the size of leaves is reduced to $\frac{1}{3}$—$\frac{1}{4}$ of the usual size and their division and hairiness seem to be more

than the average. The branches of the plant also were fewer and much shorter. The root of the plant was peculiar. It was about two feet long and $\frac{1}{4}$ inch in diameter over the greater part of its length and practically without lateral branches.

12. **Tridax procumbens** *L.*—Very common. It was found on brown rather sticky soil at Belapur on May 7, 1919. The soil round the roots contained 2·61 per cent. of available moisture.

In different situations the plant varies as regards the length of the branches, the size of the leaves, and their hairiness.

In the present instance the size of the leaves was slightly reduced and the hairiness somewhat more accentuated than usual. The root was a slender tap root 6—9 inches long and about $\frac{1}{8}$ inch in diameter, devoid of lateral branches, but with a few minute feeding roots in the lower half.

13. **Vernonia cinerea** *Less.*—Common. It was found on brown rather sticky soil at Belapur, on May 7, 1919. The soil round the roots contained 2·24 per cent. of available moisture.

The plant shows variation as regards size in different situations, and in the present instance also the plants were shorter and the leaves smaller, the root was a tap root 6—9 inches long and about $\frac{1}{8}$—$\frac{1}{6}$ inch in thickness, apparently without any lateral branches.

14. **Cocculus villosus** *DC.*—Common. It was found on light to medium black soil which was not sticky, at Belapur, on May 7, 1919. The soil round the roots contained 2·22 per cent. of available moisture.

This plant also showed only reduction in the length of the stem branches and in the leaf surface as usual. The root of the plant was about a foot and a half long and about $\frac{1}{4}$—$\frac{1}{3}$ inch in diameter apparently without any lateral branches.

15. **Morinda tinctoria** *Roxb.*—var. **tomentosa**. It was found in medium black sticky soil at Newasa * in the Ahmednagar district, on May 8, 1919. The soil round the roots contained 3.93 per cent. of available moisture.

The plant grows into a shrub or small tree, and in the present instance the plant was apparently a root-sucker. There were several other similar root suckers close by. They showed no deviation from the normal. The root was long. about $\frac{2}{3}$ inch in diameter with slender laterals spreading about eight inches below the soil.

16. **Caralluma fimbriata** *Wall.*—It was found on May 8, 1919, at Newasa in a limy soil which though dusty was inclined to be sticky, and contained round the roots 2·02 per cent. of available moisture.

* Rainfall comparable with that of Shevgaon as shown above.

The plant did not show any deviation from the normal type. Leaflessness, succulence, and the possession of a number of small feeding roots seem torenable the plant to overcome drought. The root was about 4—6 inches long. There were also numerous small feeding roots arising from part of the stem which came in contact with the dusty soil. It may be noted that the plant is used by the poorer classes as a vegetable in times of scarcity.

17. **Fagonia cretica** *L.*—Rather common. This prickly undershrub was found at Newasa on May 8, 1919, on light grey, somewhat sandy soil, containing flakes of mica. The soil round the roots contained at that time 2·06 per cent. of available moisture.

The plant shows slight variation in size in different situations. A practically leafless condition of the plant due to the reduction of the leaf-surface and the general reduction in size are characters which enable the plant to stand drought. The root was a slender tap root 6—8 inches long and about $\frac{1}{8}$ inch in diameter with one or two slender laterals in the lower half.

18. **Heliotropium supinum** *L.*—It was found in sticky silt containing Kankar nodules in a dry stream at Newasa, on May 8, 1919. The soil round the roots contained 2·46 per cent. of available moisture.

The plant shows some variation as regards the size in different situations. In the present instance it only showed a slightly reduced size as compared with the normal type. The root was slender, 6—7 inches long and $\frac{1}{8}$ inch in diameter, devoid of lateral branches.

19. **Alysicarpus rugosus** var. **styracifolius** *Baker.*—This was found in a sandy soil in a dry stream at Newasa on May 8, 1919. The soil round the roots only contained 0·80 per cent. of available moisture.

In the present instance the plant only shows a great reduction in size as it usually does in dry situations. It was only 3—4 inches high The root was a slender tap root 4—5 inches long and about $\frac{1}{10}$ inch in diameter, divided into two branches and a few very small lateral rootlets.

20. **Trichodesma indicum** *Br.*—Rather common. It was found on light yellow or brown soil at Shevgaon on May 9, 1919. The soil round the roots contained 1·70 per cent. of available moisture.

The plant shows practically no deviation from the normal beyond some reduction in size as is usual with it in such conditions. Its root was a slender tap root about 8—10 inches long and $\frac{1}{8}$—$\frac{1}{6}$ inch in diameter with several slender laterals spreading horizontally.

21. **Celosia argentea** *L.*—It was found on light, yellow or

brown soil, at Shevgaon on May 9, 1919. The soil round the roots contained 1·65 per cent. of available moisture.

The plant varies a great deal as regards its height and the size of leaves in different situations.

In the present instance it showed an extreme reduction of all the parts, the plant being scarcely three inches high though in flower. The flowering spike was scarcely $\frac{1}{6}$ inch long. The root was a slender tap root 5—6 inches long.

It may be noted that the plant is used as a vegetable by the poorer classes in times of scarcity.

22. **Heliotropium zeylanicum** *Law.*—It was found in light yellow to brown soil at Shevgaon on May 9, 1919. The soil round the roots contained 1·56 per cent. of available moisture.

The plant responded to the present conditions by undergoing a reduction in the size of the leaves to about $\frac{1}{2}$—$\frac{1}{3}$ that of the well developed ones, as is usual with the plant in such circumstances. The root was a tap root about $1\frac{1}{2}$ feet long and $\frac{1}{3}$ inch in diameter devoid of lateral branches in the upper half.

23. **Taverniera nummularia.** *DC.*—Rather common in the place. It was found in deep black sticky soil between Shevgaon and Babhulgaon on May 10, 1919. The soil round the roots contained 3·38 per cent. of available moisture.

The plant was 8—10 inches high and very much branched. It showed a distinct reduction of the leaf surface to about $\frac{1}{2}$—$\frac{1}{3}$ as compared with the well developed specimens, which seems to be its usual response under similar conditions. The root was a tap root a foot long and $\frac{3}{8}$ inch in diameter with two to three laterals placed at intervals and spreading more or less horizontally.

24. **Citrullus colocynthis** *Schrad.*—It was found in sandy soil in the bed of a dry stream between Shevgaon and Babhulgaon on May 10, 1919. The soil round the roots contained only 0·93 per cent. of available moisture.

The plant seems to respond to such arid conditions by reducing the size of the leaves to $\frac{1}{2}$—$\frac{1}{3}$ and by producing more numerous stout, bulbous-based hairs on the under side of the leaf. It has done the same thing under the present conditions, and has produced a tap root about 18 inches long and about $\frac{1}{6}$ inch in diameter.

25. **Balanites Roxburghii** *Planch.*—Common. This thorny plant was found in brownish sticky soil between Shevgaon and Pathardi* on May 11, 1919. The soil round the roots contained 3·04 per cent. of available moisture.

* The rainfall at Pathardi and Babhulgaon is practically the same as at Shevgaon.

The plant seems to respond only by slightly reducing the size of the leaves as usual in such cases. The root was a tap root about two feet long and $\frac{1}{3}$-$\frac{1}{2}$ inch in diameter. The present plant was a bush about a foot high but it grows into a shrub or small tree afterwards.

26. **Trianthema pentandra** *L.*—It was found on light yellow to brown soil at Babhulgaon* on May 12, 1919. The soil round the roots contained 1·41 per cent. of available moisture.

As usual in such cases the size of the plant showed reduction which in the present one was very great. The plant was diffuse scarcely an inch in height or in the length of its branches. The leaves were $\frac{1}{3}$- $\frac{1}{2}$ by $\frac{1}{5}$ inch, slightly fleshy in texture. The root was a slender tap root 4-5 inches long, bifurcated at the apex.

27. **Boerhaavia diffusa** *L.*—Rather common in poor soils. It was found on light grey coarse soil (murum) on the side of a hill at Sirur on May 21, 1919. The soil round the roots contained 1·20 per cent. of available moisture.

As usual with the plant in extreme cases a very great suppression amounting nearly to practical absence of the leafy parts, a reduction of the size of the leaves and the possession of a very thick rather long or conical tap root was the response of the plant in the present instance.

28. **Dipcadi montanum** *Dalz.*—Rather common in the place. It was found in light coarse soil (murum) on the side of a hill at Sirur on May 22, 1919. The soil round the root contained 2·53 per cent. of available moisture.

Perennial nature and ability to remain dormant are characteristics of the plant that enable it to tide over unfavourable times.

The plant as usual had a tunicated bulb and slender fibrous roots; having just fruited it was passing into a condition of rest. It was therefore leafless at the time.

29. **Cyathocline lyrata** *Cass.*—It was found in medium black rather sticky soil at Parner on May 23, 1919. The soil round the roots contained 2·45 per cent. of available moisture.

This species shows great variation as regards the hairiness of the leaves in different situations. In the present instance the plant was densely hairy. It had apparently finished fruiting long ago and was probably sprouting from the dormant cottony buds found in the lower axils on the stem. This might possibly be due to some rain which had fallen at Parner, a few days previous to the date of collection.

30. **Andropogon monticola** *Schultz.*—Found in light grey coarse soil (murum) on the slopes of a hill at Sirur on May 21, 1919.

* The rainfall at Pathardi and Babhulgaon is practically the same as at Shevgaon.

The soil round the roots only contained 1·20 per cent. of available moisture.

Out of the very few species of Gramineae in the present list, this grass occurred as a densely tufted perennial with fibrous roots. It is doubtful if this had been actually growing during the complete drought as it looked as if it was just sprouting when collected.

This is a fair fodder grass and its position here is noteworthy as about the only true grass in the list which perhaps continued to live or grow at the time the enquiry was made.

In addition to the above plants in this tract which were all herbaceous or shrubby, of which samples of soil were collectad for moisture determination and of which the nature of the roots was also examined, the following plants of all kinds were found living in the tract under discussion. The frequency of the plants and the peculiarities they possess have been given below. Their probable relation with drought resistance has been indicated in the summary which follows :—

TREES.

1. **Feronia Elephantum** *Corr.*— Occasional, planted. A thorny plant. The leaves are pinnate and the leaflets more or less divided and small.

2. **Ailanthus excelsa** *Roxb.*—Occasional. The leaves are pinnate and the leaflets are more or less divided.

3. **Melia Azadirachta** *L.* — ommon, planted or self-sown. The leaves are pinnate and the leaflets slightly indented.

4. **Mangifera indica** *L.*—Rather common, planted.

5. **Butea frondosa** *Konig.*—Rather common, in hilly parts. A deciduous tree.

6. **Cassia Fistula** *L.*—In hilly parts, occasional, in full flower at the time, the leaves being deciduous.

7. **Tamarindus indica** *L.*—Rather common, planted. The leaves are pinnate and the leaflets very small.

8. **Parkinsonia aculeata** *L.*—Occasional. A prickly plant with pinnate leaves and very small leaflets.

9. **Acacia arabica** *Willd.*—Very common. A prickly plant with pinnate leaves and very small leaflets.

10. **Prosopis specigera** *L.*—Rather common. A prickly plant with pinnate leaves and very small leaflets. Leaves collected and fed to cattle.

11. **Diospyros melanoxylon** *Roxb.*—Rather common in hilly parts. The leaves are tomentose.

12. **Salvadora oleoides** *Dene.*—Not very common, planted? The leaves are rather small and narrow. They are provided with

layers of palisade tissue on either side and seem to contain a lot of storage tissue also.

13. **Ehretia aspera** *R.*—In hilly parts not very common. The leaves are more or less hairy.

14. **Vitex Negundo** *L.*—Occasional. The leaves are pinnate and the leaflets more or less divided and hairy.

15. **Euphorbia Tirucalli** *L.*—Rather common, planted. Almost always without leaves.

16. **Bridelia retusa** *Spr.*—In hilly parts, not very common. Slightly hairy.

17. **Ficus bengalensis** *L.*—Rather common, planted or self-sown. Slightly hairy.

18. **Ficus retusa ?** *Linn.*—Rather common, planted.

19. **Phoenix sylvestre** *R.*—Not common. The leaves are pinnate and contain a lot of sclerenchymatous tissue along both sides of the leaf in addition to the palisade tissue which occupies the whole leaf.

SHRUBS.

20. **Capparis aphylla** *Roth.*—Very common throughout, quite leafless and prickly.

21. **Capparis divaricata** *Lam.* In hilly parts not very common. A prickly plant. The leaves are small and somewhat thick. There is a thick cuticle on the upper surface and the leaf is full of palisade tissue.

22. **Cadaba indica** *Lam.*—In hilly parts, not common. The leaves are slightly hairy.

23. **Gymnosporia Rothiana** *Laws.*—Rather common in hilly parts. Nearly leafless and with thorny branches.

24. **Rhus mysorensis** *Heyne.*—Rather common in hilly parts. The branches are thorny. The leaves are pinnate and the leaflets small, more or less divided and hairy.

25. **Cassia auriculata** *L.*—Very common everywhere, with pinnate leaves and small leaflets.

26. **Mimosa hamata** *Willd.*—A prickly plant, rather common in hilly parts. Leafless at the time.

27. **Dichrostachys cinerea** *W. & A.*—Occasional. A thorny plant. The leaves are pinnate and the leaflets very small.

28. **Opuntia nigricans** *Haw.*—Extremely common everywhere. The very thorny phylloclades are flattened like leaves, the true leaves being always absent.

29. **Calotropis procera** *Br.*—Very common. The leaves are hairy and contain a milky juice.

30. **Clerodendron Phlomoides,** *L.f.*—Not very common, leafless at the time.

31. **Jatropha Curcas** *L.*—Not very common.

32. **Flueggea leucopyros** *Dalz.*—Occasional in hilly parts. A plant with thorny branches and very small leaves.

33. **Agave vivipara** *Wight.*—Occasional, planted. The prickly leaves are very thick and contain much sclerenchymatous tissue in addition to the thick cuticle, groups of sunken stomata and a lot of palisade and water storage tissue, the latter of which occupies the whole of the central portion.

Climbing Shrubs.

34. **Vitis pallida** *W. & A.*—Occasional in hilly parts. Leafless at the time.

35. **Gymnema sylvestre** *Br.*—Occasional. A very hairy twiner.

36. **Cryptostegia grandiflora** *Br.*—Occasional. The leaves are rather tough and contain a milky juice. They also seem to contain what looks like transverse bands of water storage tissue. This tissue surrounds the vascular portions. It is noteworthy however that the sponge tissue contains very large air spaces. There is a thick cuticle on the upper epidermis and no stonata present.

37. **Rivea hypocrateriformis** *Chois.*—Occasional. A very hairly twiner.

Herbaceous plants.

38. **Cleome viscosa** *L.*—Not Common.

39. **Polygala erioptera** *DC.*—In fields not common.

40. **Triumfetta rotundifolia** *Lam.*—Rather common on the borders of fields.

41. **Tribulus terrestris** *L.*—Rather common. A very hairy prostrate plant having a prickly fruit.

42. **Indigofera cordifolia** *Heyne.*—Rather common in poor soils.

43. **Corchorus Antichorus** *Raens.*—Not common ; in poor soils.

44. **Blumea Malcolmi** *H. f.*—Not common ; in waste places. A very hairy plant.

45. **Vicoa auriculata** *Cass.*—Not common ; in poor soils.

46. **Flaveria contrayerba** *Pers.*—Not common; not in a good condition.

47. **Evolvulus alsinoides** *L.*—Rather common in poor soils.

48. **Lippia nodiflora** *Michx.*—Not very common.

49. **Achyranthes aspera** *L.*—Not very common. A very hairy plant.

50. **AErua javanica** *Juss.*—Not very common. A very hairy plant.

51. **Aristolochia bracteata** *Retz.*—Occasional.

GRASSES.

52. **Pennisetum Alopecuros** *Ness.*

53. **Ischaemum pilosum** *Hack.*—Very common in black soil fields where it shows large dry patches which were dug up and fed to cattle.

54. **Andropogon pertusus** *Willd.*

55. **Andropogon annulatus** *Forsk.*

56. **Cynodon dactylon** *Pers.*—Found green only near moist places from where they were dug up and fed to cattle.

All these grasses dry up in the absence of water but sprout again when it is available.

When we try to consider the points brought out by the above observations the first thing noticed is that according to the nature of the soil the amount of available moisture varies roughly from 1-4 per cent. during the hottest and driest part of the year. In the sands the available moisture was under 1 per cent. In the course 'murum' soils it was between 1 and 2 per cent. In the black soils with their very large amount of clay the available water even at this time rose to between 3 and 4 per eent. This seems to be the limit of growth of any phanerogamic vegetation whatever on these various classes of land.

A general reduction in the size of the plant and of its aerial parts such as branches, leaves, &c. and the development of a tap root (diagrams of some of the typical roots are attached) were characteristic, though the latter was not quite universal. There are two dicotyledons in the list which even under the very highly xerophytic conditions did not show an appreciable tap root. The first of these is *Tragia cannabina* L. and the second *Caralluma fimbriata* Wall. The primary root of the former of these seems to have been soon divided into several secondary branches. These branches are long and rather stout however, and descend obliquely into the soil so that they can perform the same function as a tap root. This plant is moreover well supplied with other means of decreasing transpiration andhence economising

the supply of water, such as a partially reduced leaf surface and a thick covering of hairs. The second plant mentioned (Caralluma) had a large number of feeding roots developed and I suspect that it made use of hygroscopic water on the surface of the particles of soil containing much lime on which it grew. Moreover the plant has no leaves and the stems are more or less succulent and possess laticiferous tissue.

Two monocotyledons appear in the main list, and these have of course no tap roots. One is *Dipcadi montanum* Dalz. the other is *Andropogon monticola* Schult. The former of these has however a tunicated bulb. It had no leaves at the stage at which it was observed. The plant had just then fruited and was passing into a condition of rest. My colleague Mr. H. P. Paranjapye was able to get me a number of flowering specimens a month later. The latter—*Andropogon monticola* has fibrous roots like most grasses, is perennial and usually remains dormant through the hot weather in the absence of special water supply. It had produced some green leaves in the present instance probably because there had been slight rain, not sufficient however to affect the water content of the soil, a few days before the specimen was collected.

The effect of the extreme drought on the size of the plant and the size and character of the leaves is shown in a number of species, the size of both being generally reduced and the divided character and hairiness of leaves in a very few of them emphasised (see Nos. 5, 8, 11, 12, 24 and 29). Reduction in the size of the plants is most marked in *Polygonum plebejum* R. Br., *Trianthema pentandra* L., *Celosia argentea* L. *and Alysicarpus rugosus* var. *styracifolius* Baker. The reduction of the size of these plants is from one-fifth to one-tenth of the normal, or even further. The increased hairiness of the leaves or leafy organs in a few cases, the pronouncedly branched character of the stem or its well known prostrate or diffuse nature, and the usual prickliness of a large number of plants are all very characteristic of a dry tract.

The plants in the supplementary list also show similar characteristic peculiarities. The trees and shrubs of course find no difficulty in absorbing moisture from the depths of the soil where their deep descending roots can reach, provided the plants do not happen to grow in very rocky and dry situations. In addition to this great advantage some of them also possess other minor peculiarities which might help them to withstand drought. Thus some of them are leafless or shed their leaves to a greater or less extent and reduce the transpiring surface, *e.g.* Nos. 5, 6, 11, 15, 20, 23, 26, 28, 30, 34. The leaves of some are always much divided and have very small

leaflets which also serves the same purpose as above, *e.g.* Nos. 1, 7, 8, 9, 10, 24, 25, 26, 27. Some plants again are more or less hairy and protected from the scorching sun, *e.g.* Nos. 2, 5, 11, 13, 14, 24, 29, 35, 37. Some have got rather thickish leaves which are well protected against loss of water, *e.g.* Nos. 12, 19, 21, 33 and 36. Some plants again are protected from desiccation by having in their tissues latex or a kind of milky juice, *e.g.* Nos. 29, 36. Nos. 12 and 36 seem also to contain some water storage tissue. No. 36 again has palisade tissue on both sides of the leaf. As regards the herbaceous plants, most of them also are more or less hairy, Nos. 41, 42, 44, 47, 49 and 50 being more particularly so. Such of them as are not at all hairy are only Nos. 43 and 46. The young leaves of No. 51 are puberulous though later on many of the hairs drop off. No. 43 has very small and somewhat wrinkled leaves while Nos. 46 and 51 have leaves which are inclined to be somewhat fleshy.

It is needless to say that several of these plants also show a great reduction in size under the abnormally dry conditions.

The number of grasses found actually living is disappointing but it indicates *Andropogon monticola* Schult., and possibly *Ischaemum pilosum* Hack. to be the most resistant to drought of the common grasses of the Deccan, the former occurring in murum soils, the latter in black soils. *Andropogon annulatus*, Forsk. and *Andropogon pertusus* Willd. were found to be green and in flower in a small patch at Parner, but their greenness was probably due to some rain which had fallen at Parner a few days previously.

The list of plants observed is not quite exhaustive since it was not possible to note each and every species in such a short time. The list is however fairly representative of the tract at the given time, though in a normal year perhaps it would have been possible to find many more species which were unable to survive this year.

The summary of observations shows rather clearly that beyond the average fluctuations in the characters of the various plants found living we do not find any great deviations even in such abnormal years.

It may be mentioned here that the enquiry which was perhaps the first of its kind on this side of the Bombay Presidency was undertaken solely at the suggestion of Dr. H. H. Mann the present head of the Bombay Agricultural Department to whom I feel greatly indebted.



Explanation of the Plate

No. 1. *Boerhaavia diffusa L.*
„ 2. *Tridax procumbens L.*
„ 3. *Cucumis trigonus* Roxb.
„ 4. *Citrullus colocynthis* Schrad.
„ 5. *Taverniera nummularia* DC.
„ 6. *Leptadenia reticulata* W. & A.
„ 7. *Dipcadi montanum* Dalz.
„ 8. *Lepidagathis trinervis* Nees. var *asperrima*?
„ 9. *Tragia cannabina L.*
„ 10. *Caralluma fimbriata* Wall.

SPECIES NOVAE INDIAE ORIENTALIS

Decas I.

Myriophyllum spathulatum Blatt. & Hall. Spec. nov. (*Haloragidaceae*).

Herba paludosa, glabra, ramis natantibus fortibus spongiosis teretibus, diametro 7mm attingentibus. Folia verticillata, pectinatim pinnatifida segmentis capillaceis.

Folia floralia infima verticillata, caetera alterna solitaria, vel 2-3-nata, vel 2-3-fasciculata, lineari-spathulata, infima interdum apice acuta, 3 circiter cm longa, minutim serrata in parte superiore rotundato. Flores axillares sessiles solitarii, formantes racemos terminales vel laterales longos, 60 cm attingentes, hermaphroditi, bracteis 2 scariosis rhomboideis irregulariter dentato-serratis. Calycis tubus ovario adnatus ; limbus 4-lobus lobis minutis fere orbiculatis viridescentibus. Petala 4 magna imbricata concava scariosa albida. Stamina 4 ; antherae subsessiles, largae et longissimae, quadriloculares, tetragonae, ad angulos rotundatae. Ovarium aeqe longum ac latum, quadriloculare, 4-ovulatum, tetragonum angulis carpellorum dorsalibus acutis ; styli 4 brevissimi, carnosi, formantes pyramidem brevem, parte stigmatica terminali viridi.

Fructus maturus in planta viva 4 mm longus et latus ; carpella dorso rotundata, non tuberculata nec scabra ; inter dorsa carpellorum vicina sulcus latus sed minime profundus ; ad apicem fructus 4 puncta nigra indicantia loca originis stylorum. Semina ca 3 mm longa, $1\frac{1}{2}$ mm lata, lateraliter compressa, rhomboidea in sectione transversali, plus minusve rotundata ad extremitates, duabus faciebus exterioribus echinatis.

Nota : Cautio magna est adhibenda in describendo fructu. Si fructus maturus separatur a planta et arescit, vel si tota planta cum fructu sinitur arescere, pericarpium contrahitur, dorsa carpellorum fiunt acuta et sulci interdorsales profundi, totaque superficies cooperta apparet tuberculis plus minus acutis ; e contra autem, si fructus maturus remanet in planta viva, tuberculi non apparent fructusque dirumpitur in 4 partes.

Vicina est haec species *Myriophyllo tuberculato* Roxb. a qua tamen differt foliis floralibus spathulatis, floribus albidis, calyce, floriferis racemis longissimis non-nudiusculis, forma bractearum, stigmate viridi, non-fimbriato.

Lecta a C. McCann in palude vici Khandalla (Western Ghats) Provinciae Bombayensis, altit, 500 m, mense Novembri 1916 (Herb. St. Franc. Xav. Bomb. no. 12634). Vide Fig. 1.

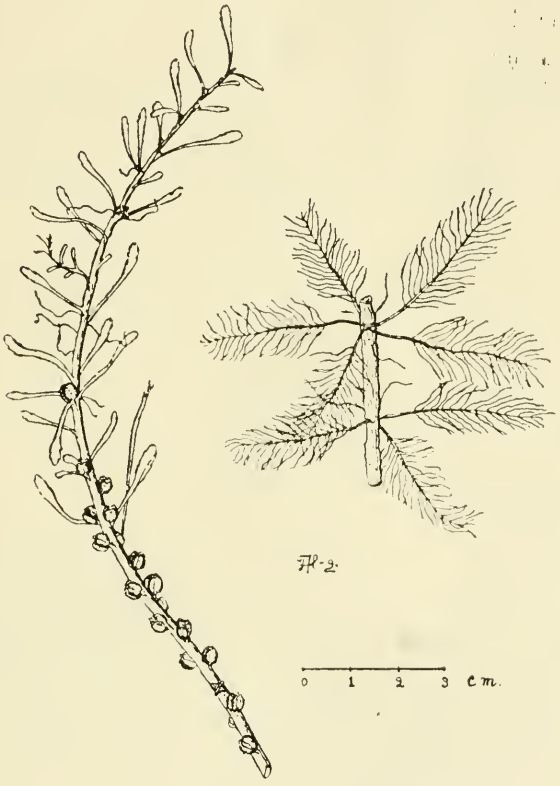


Fig. 1. MYRIOPHYLLUM SPATHULATUM, BLATT. & HALL.

Del. F. Hallberg.

Bonnayodes Blatt. & Hall. Gen. Nov.

Clayx 5-partitus segmentis angustis. Corollae tubus cylindricus; labium posticum exterius ovatum, 2-fidum, anticum maius, lobis 3 subaequalibus. Stamina 2 postica perfecta, tubo affixa, filamentis sursum incrassatis; antherae loculis divaricatis; staminodia 2 antica, fauci affixa, integra, clavata, glabra. Stylus apice bilamellatus. Ovula

in loculis numerosa. Capsula breviter oblonga, calyce longior, septicide dehiscens. Semina numerosa, longitudinaliter costata.

Herbae erectae vel ascendentes, glabrae. Folia opposita semel vel bis profunde incisae. Flores axillares, generatim unus, interdum duo ad internodia pedicellis ebracteolatis.

Pertinet hoc genus ad tribum *Gratiolearum* ordinis *Scrophulariacearum*, subtribum autem *Vandelliearum*.

Bonnayodes vicina est tribus generibus: *Bonnayae*, *Ilysanthi*, necnon *Limnophilae*. Floribus refert *Bonnayam*, capsula *Ilysanthem*, foliis quasdam *Limnophilas*. Differt autem a *Bonnaya* capsula breviter oblonga et foliis, ab *Ilysanthe* forma staminodiorum, et foliorum, a *Limnophila* denique inter alia numero staminum perfectorum.

Bonnayodes limnophiloides Blatt. & Hall. Spec. Nov.

Herba annua, erecta vel ascendens, caulibus multis rubescentibus, ramosa; caules ramique fortes, plus minusve quadrangulares, speciatim in partibus superioribus; internodia 10-15 mm longa; radices numerosae ca 2 cm longae, albidae. Folia opposita, rubescentia, 15 mm ad summum attingentia, generatim divisa usque ad basim in segmenta 2-3 linearia, segmentis iterum bifidis ad medium et interdum secunda vice per tertiam partem: lobi patentes, apice acuti.

Flores axillares, generatim unus, interdum 2 ad internodium. Pedicelli fortes, quadrangulares, sursum incrassati, rubescentes, glabri, 10 mm attingentes, patentes, interdum recurvati in fructu, ebracteolati. Calyx 5 mm longus, divisus fere ad basim in 5 lobos subaequales, lineari-subulatos glabros rubescentes. Corolla 8-9 mm longa, lilacea, tubo cylindrico dimidiam partem totius corollae attingente pallidiore. Labium posticum exterius, antico brevius, ovatum, bifidum, lobis apice subacutis, anticum lobis 3 rotundatis subaequalibus, pilis paucis intus formantibus duas lineas ad sinus labii terminantes. Staminodia 2 antica, integra pallide lilacea, glabra, clavata, fauci affixa. Stamina 2 postica perfecta, tubo affixa, sursum multum incrassata, filamentis pallide lilaceis, glabris; antherarum loculi 2, longitudinaliter dehiscentes, contigui, divaricati. Stylus pallide lilaceus subcompressus, ovario aequilongus apice bilamellatus, lamellis albidis intus stigmatosis. Ovarium, purpureum, glabrum.

Capsula calyce dimidio longior, duplo longior quam lata, 2-valvata, scariosa, apice obtusa. Semina numerosa, minuta, subcylindrica vel falcata, longitudinaliter costata, punctata.

Lecta a F. Hallberg in fundo sicco laci Bushy Lake qui vocatur in regione Lonavla in Montibus Western Ghats, Provinciae Bombayensis, altitudine ca 550 m (Herb. S.X.C. no. 9450). Vide Fig. 2.



Fig. 2. Bonnayodes Limnophiloides, Blatt. & Hall.
Del. F. Hallberg.

Leucas macrantha Blatt. & Hall. Spec. nov. (Pertinet ad Sect. *Plagiostomatis* ordinis *Labiatarum*).

Herba procumbens, basi lignosa. Caules ramique qudrangulares, sulcati, parce hirsuti. Rami ascendentes. Folia lineari-lanceolata vel lanceolata, decurrentia in petiolum, sessilia vel subsessilia, usque ad 40 mm longa et 8 mm lata, integerrima, subacuta, nervis infra et marginibus hirsutis, interdum parce hirsuta ubicunque.

Folia floralia caeteris similia, sed remote et distincte serrata vel dentata. Verticillastri dense multiflori usque ad 20 flores continentes, terminales, pedicellis minutis. Bracteolae numerosae, aciculares, calyci aequilongae, longe hirsutae. Calyx tubulosus, subventricosus, 10-nervatus, usque ad 10 mm longus, dentibus 10 longis acicularibus, dente uno superiore longiore et latiore ; tubus incurvus, delicatule pubescens, nervis dentibusque hirsutis, fauce fere occlusa cono pilorum validorum calycis dentibus multo breviorum, intus glaber. Corolla alba, 22 mm longa ; tubus subinclusus, intus nudus ; limbus 2-labiatus, labio postico recto, concavo, dense albo-villoso, antico patente, plano, 3-fido, 15 mm longo (ter habens longitudinem labii postici), lobo medio maximo 14 mm lato, labis lateralibus minimis,

revolutis, apice acutis, parte dimidia inferiore labii antici albo-pubescente. Stamina 4, didynama, sub galea ascendentia; antherae rubro-brunneae, per paria approximatae, 2-loculares, loculis divaricatis. Stylus subulatus, lobo postico rudimentali. Nuculae ovoideae, 3 mm longae, triquetrae, immaturae longitudinaliter rugosae.

Species haec nova vicina est *Leucae strictae*, a qua tamen distinguitur habitu procumbente, foliis subacutis, foliis floralibus dentatis vel serratis, floribus maioribus, tubo corollae nudo, labio inferiore multo maiore ejusque lobis lateralibus acutis.

Lect aa F. Hallberg in vico Mt. Abu Rajputanae regionis, altit. 1200 m, mense Octobri 1916. (Herb.S.X.C. no. 768).

Euphorbia khandallensis Blatt. & Hall. Spec. nov. (Pertinet ad Sect. *Rhizanthii*).

Rhizoma tuberosum cylindricum, usque ad 30 cm longum, 10 cm latum, totum subterraneum, generatim apice bifurcans, furcis duos cm attingentibus. Radices irregulariter surgentes, etiam immediate infra folia. Folia omnia radicalia, oblanceolata vel obovata, vel oblonga, interdum obliqua, apice obtusa vel retusa, basi cuneata, in petiolum attenuata, usque ad 33 cm longa, 11 cm lata, subsessilia vel petiolata petiolo 5 cm attingente, carnosa, margine plus minusve undulata, costa centrali depressa in pagina superiore, prominente in inferiore, nervis lateralibus circa 12, obscuris superne, prominentibus inferne.

Pedunculi terminales dichotomi saepe quater vel quinquies, carnosi, viridescentes vel rubescentes, tota inflorescentia 18 cm attingente; pedunculus communis usque ad 9 cm longus. Bracteae ad dichotomias scariosae, ad primam quidem dichotomiam late triangulares acutae, 5-6 mm longae, caeterae autem semi-cylindricae, semi-amplexicaules, abrupte acuminatae, apice rostro reflexo munitae. Involucra in dichotomiis sessilia terminalia podicellata pedicellis usque ad 15 mm longis, breviter campanulata, 5-6 mm in diametro, rubescentia, lobis albis, apice truncatis fimbriato-pectinatis, glandulis transverse et late oblongis. Antherae purpurascentes. Ovarium purpureum. Styli basi tantum connati.

Capsula trium coccorum 2-valvatorum, 4 mm longa, 7-8 mm lata, trisulcata, stipitata pedicello usque ad 12 mm longo; cocci fere rotundi angustissime carinati, minime compressi. Semen perfecte sphaericum, diametro 3 mm, nigrum et albo-variegatum.

Folia plantarum in locis fertilibus et umbrosis crescentium maiora et flavo-variegata, in substrato autem sterili et soli exposito rubro-variegata in pagina inferiore.

Species haec multis in characteribus *Euphorbiam acaulem* Roxb. refert, sed distinguitur ab ea forma bractearum, colore involucri, coccis minime compressis, stylis basi tantum connatis, semine perfecte

sphaerico, rhizomate multo longiore, foliis maioribus, petiolatis nervosis, variegatis.

Legit hanc plantam fructificantem C. Mc Cann prope vicum Khandalla in Montibus Western Ghats, Provinciae Bombayensis, altitud. 500 m, mense Aprili 1918. Specimen Bombay apportatum floruit mensibus Martio et Aprili anni sequentis. (Herb. S. X. C. no. 12678). Vide Fig. 3.

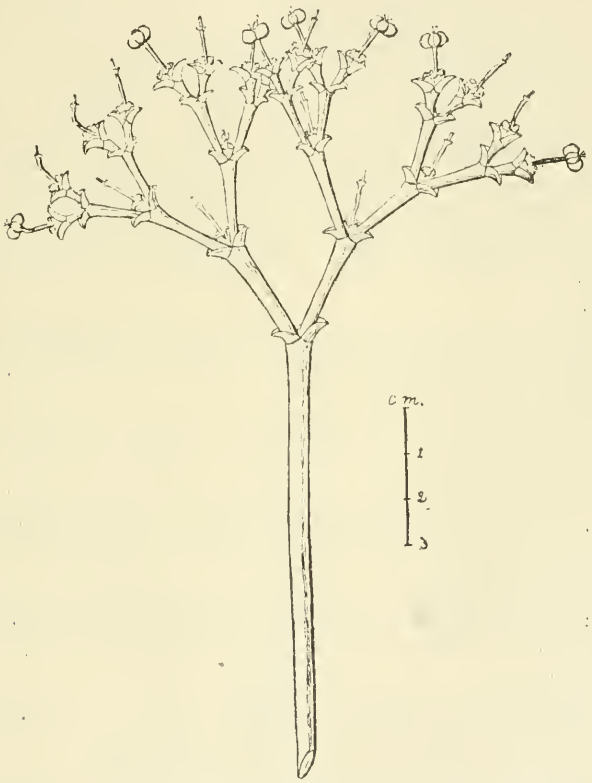


Fig. 3. EUPHORBIA KHANDALLENSIS, BLATT. & HALL.

Del. C. McCann.

Lemna maxima Blatt. & Hall. Spec. nov.

Frondes herbaceae, utrimque planae, non-spongiosae, natantes vel in terra humida crescentes, tenui-coriaceae, fragiles, opacae, symmetricae, suborbiculatae, late ovatae vel obovatae, usque ad 13 mm longae et 10 mm latae, 9-nervosae, pagina superiore atro-virides nitidae, inferiore atropurpureae, e pagina inferiore radicellas multas (usque ad 17) fortes 3 cm longas fasciculatas emittentes, quando juvenes sessiles.

Flores et fructum non observavimus.

Species haec vicina est *Lemnae polyrrhizae* L. a qua distinguitur foliis multo largioribus, nervorum numero frondium, radicellis multo numerosioribus.

Legimus plantam hanc in rivulo vici Achalgar in Monte Abu, Rajputanae regionis, altit. 1300 m, mense Octobri 1916. (Herb. S.X.C. no. 1856).

Crescit quoque in terra humida umbrosa rivulo vicina inter herbas. Est hic locus unicus in quo observavimus hanc speciem.

Lemna minima Blatt. & Hall. Spec. nov.

Frondes $2\frac{1}{2}$ mm longae vel breviores, asymmetricae, obovatae vel obovato-oblongae, vel orbiculatae, utrimque pallide virides, pagina superiore tuberculis munitae; juvenes sessiles in parentibus, separantes a parentibus quando attingunt dimidiam magnitudinem naturalem, interdum 3 conjunctae ante separationem, unica tamen radicella munitae. Radicella solitaria, fortis, circa 15 mm longa, calyptra acuta circumdata.

Stamina bina filamentis longiusculis filiformibus, antheris dithecis bilobis, lobis rotundis; pollen irregulare, rotundo-angulare. Stylus brevissimus stigmate lacero.

Semen horizontale, hemianatropum, ovatum, raphide prominente in parte tertia superiore.

Species haec sub diverso respectu vicina est *Lemnae minori* L. et *L. paucicostatae* Hegelm. Distinguitur a *Lemna minore* foliis minoribus asymmetricis, a *Lemna paucicostata* seminibus horizontalibus hemianatropis.

Legimus plantam in lacu templi Dilwarae in Monte Abu, Rajputanae regionis, altit. 1200 m, mense Octobri 1916. (Herb. S.X.C. no, 17456.)

Dendrobium actinomorphum Blatt. & Hall. Spec. nov. (*Orchidaceae*). Pertinet ad Sect. *Eu-Dendrobii*.

Herba epiphytica pendula, radicibus numerosis gracilibus. Caules floriferi aphylli, 25 cm longi, articulati; internodia crassa, carnosa, cylindrica, circa 2 cm longa, infra nodos subincrassata, viridia, unumquodque inclusum in vagina scariosa, multinervosa nervis parallelis, surgente e nodo et extendente usque ad medium internodium subsequens, apice 1 cm lata, profunde emarginata; vaginae nervi 9 prominentes, fortes, albi alternantes cum 10 aliis ninus conspicuis. Internodium ultimum brevissimum, conicum.

Caules folia gerentes ad basim caulium florigerorum post anthesim apparentes. Folia disticha; lamina (foliorum juvenum?) ca 10 cm longa, 5 nervis conspicuis et multis inconspicuis; petiolus amplexicaulis, multinervosus.

Pedicelli fortes, $2\frac{1}{4}$-$3\frac{1}{2}$ cm longi, anthesi durante rubescentes, virides post anthesim. Flores gemini vel solitarii e nodis surgentes, subregulares, 3 cm in diametro; sepala et petala longitudine subaequalia, pallidissime rubescentia ; sepala 15 mm longa, 7-8 mm lata, oblonga, apice subobtusa vel mucronata; petala cum labello late ovato-oblonga, 15-17 mm longa, 10 mm lata, apice rotundata vel retusa. Columna brevissima, alba, basi duobus processibus atro-purpureis munita, ad quorum basim dorsalem duae sunt caveae profundae (nectaria?). Anthera terminalis, opercularis, 2-locularis. Pollinia 4, cerea, per paria in loculis collateralia, libera, inappendiculata.

Capsula circa 2 cm longa, 1 cm lata, pyriformis, processu cylindrico clavato coronata.

Species haec absentia menti anomala. Distinguitur etiam sepalis petalisque conformibus.

Lecta a C. Mc Cann prope stationem viae ferreae Castle Rock in Provincia Bombayensi, mense Martio 1919 (Herb. S. X. C. no. 13768). Vide—Fig. 4.

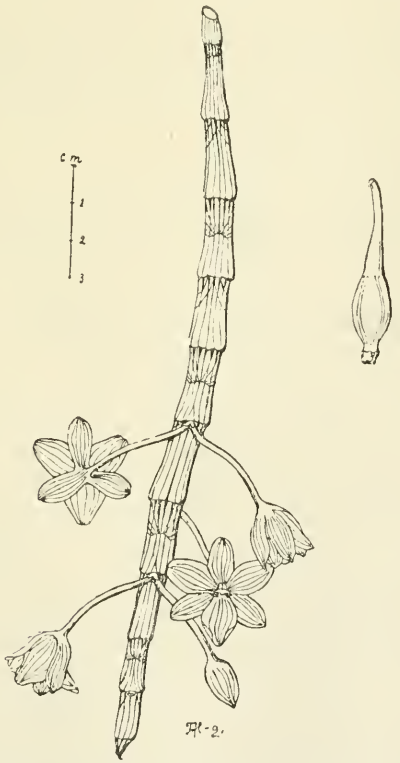


Fig. 4. Dendrobium actinomorphum, Blatt. & Hall.

Del. F. Hallberg.

Pancratium St. Mariae Blatt. & Hall. Spec. nov. (*Amaryllidaceae*).

Herba perennis glabra. Bulbus globosus, diametro 4 cm, tunicis membranaceis, pallide brunneis, venosis; cervix distincta, 2-5 cm longa, interdum cervices duae, quarum ex maiore surgit scapus. Radices surgentes e margine disci basilaris 2 cm diametro attingentis. Folia hysteranthia circa 5, linearia carnosa, scapo aequilonga vel sublongiora, 15 mm lata, apice obtusa.

Scapus fortis, 15-20 cm altus, delicatule longitudinaliter striatus, anceps, e basi crassiore paullatim diminuens, diametris ad basim 7 et 4 mm. Spatha unica, umbellatim 4-5 flora, hyalina, nervosa, circa 25 mm longa, late ovata, subinaequaliter bifida, lobis acuminatis. Pedicelli variabiles, subabsentes usque ad 10 mm longi, subtrigoni, fortes. Perigonii tubus usque ad 25 mm longus, infra viridescens, supra albus, subtrigonus, gracilis, apice subampliatus; laciniae albae, circa 22 mm longae, 5 mm latae, lanceolatae. Corona 7-10 mm longa, cylindrica, rugosa, laciniis 12 deltoideis 2 mm longis; filamenta subulata laciniis breviora et angustiora, texturae firmioris. Antherae linearifalcatae, inaequaliter versatiles, circa 6 mm longae, 3/4 mm latae, flavae. Ovarium ellipsoideo-trigonum, 8 mm longum, 5 mm latum, viride, ovulis numerosis. Stylus filiformis, 35-40 mm longus, tubo inclusus; stigma parvum, capitatum.

Flores evanescunt post horas circiter 18.

Vicina species nova *Pancratio parvo*, differt tamen scapo forti, numero florum, perigonii tubo multo breviore, laciniis lanceolatis, stylo incluso.

Lecta a C. Mc Cann prope St. Mary's Villa in vico Khandalla Montium Western Ghats Provinciae Bombayensis. Floruit mense Junio. (Herb. S.X.C. no. 19854). Vide Fig. 5.

Scilla viridis. Blatt. & Hall. Spec. nov. (*Liliaceae*).

Herba perennis. Bulbus ovoideo-globosus, 5 cm longus, 4 cm latus, tunicatus, pallide flavus, solidus, aliquantulum amarus, odore tuberis *Solani tuberosi*; radices usque ad 10 cm longae, fortes, cylindricae pallescentes, surgentes e margine disci basilaris ca 15 mm diametro. Folia hysteranthia.

Scapus 50 cm altus, gracilis, teres, nitidus, olivaceo-purpureus, flores gerens in dimidia parte superiore. Racemus laxus, 40 circiter florum, duobus tertiis inferioribus sine flore quando summus tertius fert 3 circiter flores appertos. Bracteae minimae, rubescentes, 2 mm longae, angustae, carinatæ, obtusae, duabus callositatibus ad basim in pagina inferiore munitae assumentibus formam elongatam post anthesim, deciduae. Pedicelli fortes, 10—15 mm longi, articulati in scapo, versus apicem subreflexi. Gemmae pyriformes, virides. Perigonium vires-

cens, 15 mm diametro, stellatum, persistens, clausum post anthesim et tunc colore purpurascens; segmenta 6, subaequalia, exteriora sublatiora, oblongo-subacuta, interiora vero oblongo-obtusa, nervo centrali carnoso, incrassato et colore atro-viridi. Stamina 6 basi segmentorum affixa; filamenta fortia, latiora in parte superiore, dimidiam segmentorum longitudinem attingentia; antherae breves, $1\frac{1}{2}$ mm longae, oblongæ, dorsifixae, valde decurvae post dehiscentiam, loculis introrsum

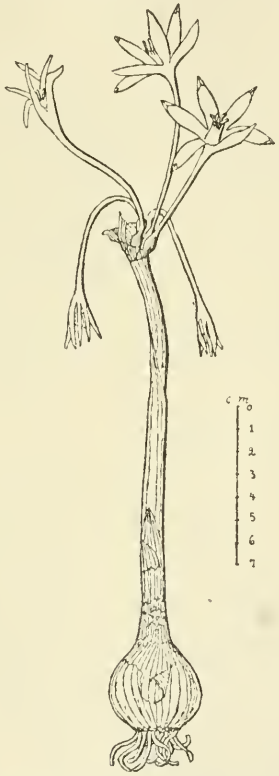


Fig. 5. PANCRATIUM ST. MARIAE, BLATT. & HALL.

Del. C. McCann.

dehiscentibus. Ovarium ovoideum, subtrigonum, 3-loculare, ovulis in singulis loculis 3-4. Stylus ovario subaequilongus, fortissimus, clavatus, trigonus; stigma parvum, triangulari--capitatum, centro depresso.

Fructum non vidimus.

Legit bulbum simul cum foliis C. Mc Cann prope vicum Khandalla in Montibus W. Ghats, Provinciae Bombayensis, mense Septembri 1918. Bombay apportatum floruit Mense Martio 1919. (Herb. S.X.C. no. 14500).

Commelina heterosperma Blatt. & Hall. Spec. nov. (*Commelinaceae*). Pertinet ad Sect. *Heterocarpi*.

Herba annua, debilis, prostrata, glabrescens exceptis vaginis, nodis radices edentibus. Internodia circa 7 cm longa. Folia lanceolata, acuta, multinervata, sessilia in vaginis laxis. Vaginae margine ciliatae.

Pedunculi in axillis superioribus, subpubescentes, tenues, brevissimi usque ad 1 cm attingentes. Spatha ovato--cordata, ad ultimum acuminata, complicata, subglabra, generatim circa 2 cm longa, 1½ cm lata, lobis basalibus rotundatis. Cyma intra spatham bifida, ramo uno tantum uni-floro, inferiore ad stipitem nudum reducto. Sepala membranacea, 3 mm longa, extimo ovato, subacuto, duobus interioribus suborbicularibus, obtusis. Petala caerulea, reniformia; lamina 4 mm longa et lata, quorum lateralia distincte unguiculata, impar autem fere sine unguicula. Stamina perfecta 3, filamentis caeruleis, rectis, glabris, filiformibus; anthera una alba, loculis marginibus flavis, infra divergentibus, duae aliae albidae, loculis marginibus nigris, subparallelis; pollen flavum. Staminodia tria, staminibus aequilonga vel eis subbreviora; filamenta gerentia 4 processus parvos clavatos flavos ordinatos in forma crucis, quorum duo sunt aliis longiores. Ovarium pallide viride. Stylus caeruleus, rectus, filiformis, glaber. Stigma minutum, trigonum, capitellatum.

Capsula trilocularis. Loculi duo antici 1-2 continentes semina, loculicide dehiscentes. Semina libera in loculis, nigra, punctata, irregulariter rugosa, squamulis minimis parcissime sparsa. Hilum circulare in superficie curvata prope marginem positum, puberulum, coniculo brevissimo centrali munitum. Si duo adsunt semina in uno alterove loculo antico, facies contiguae sunt planae, alioquin rotundatae; facies centroversa linea elevata munita. Loculus posticus primum indehiscens ultimatim separata a parente dehiscens, minor loculis anticis neque apicem capsulae attingens. Semen brunneum, ellipsoideum, laeve, facie una curvata, duabus autem planis angulum obtusissimum formantibus, minime puberulum.

Observavimus dehiscentiam per longum tempus. Post loculorum dehiscentiam anticorum spatha separatur a parente, sed capsulae locus posticus remanet clausus. Carina dorsalis vix conspici potest et semen loculum implet. Capsula autem madefacta carina dorsalis apparet longitudinalis quae ultimatim dirumpitur et liberat semen.

Vicina est species haec *Commelinae Forskalaei* Vahl, a qua distinguitur seminum colore, sculptura, dimorphismo, numeroque seminum in loculis anticis.

Lecta a C. McCann in collibus Igatpuri Ghats qui vocantur, in Provincia Bambayensi, altit. 600 m, mense Septemberi 1917 (Herb. S. X. C. no. 12786).

DESCRIPTION OF THE INFLORESCENCE OF AMORPHOPHALLUS CAMPANULATUS *BL.*

By T. R. Khadilker, B.A.,

Agricultural Department, Bombay, Poona.

The inflorescence, a short description of which is given below, is of a well-known plant Amorphophallus campanulatus Bl. (*Suran* in Marathi) belonging to the natural order Aroideæ.

Almost all of us know this *Suran* plant and also the value of its under-ground corm as an article of vegetable diet. Description of this plant also occurs in many Botanical works, such as the Floras of Cooke and Hooker for example. However, the inflorescence of this plant is not an object of common observation. With this in mind, it is hoped that a figure of it accompanied by a short description will not be out of place here.

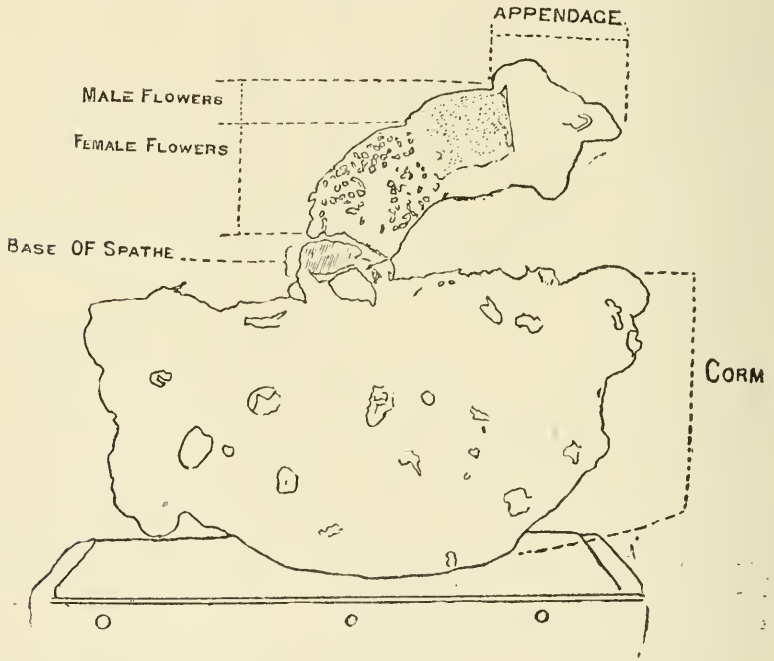
The inflorescence :—It is an elongated, slightly curved, cylindric, densely flowered spadix, divided into three distinct coloured portions. The top portion of it constitutes what is called an appendage. The portion below the appendage looks like a broad yellow band which is full of yellow coloured male flowers. The third and the last portion is also as broad as the above one and is full of brown female flowers. At a little distance below the last band there is a place of the origin of the spathe and right at the base of the peduncle we see many scale leaves surrounding the central column. The spadix is situated in the centre of the top of the bulky corm.

The total length of the spadix examined was 23 cm. of which 3 cm. was the vertical height of the appendge, 5 cm. the vertical height of the part possessing yellow coloured flowers, and the portion below of brown coloured flowers was 7 cm. The general circumference of the spadix was 18 cm.

Appendage :—It is leathery, of dark purple colour, and with the thickness of its wall—3 cm. It is hollow inside. The inner surface of the wall is spongy and marked with ridges. It appears conical if we pull up the middle blunt tip with our fingers. Its conical structure falls in folds on the top of the inflorescence.

Yellow male flowers :—This portion of the inflorescence is yellow coloured and densely studded with sessile yellow anthers. Neither filament nor perianth is present in these male flowers.

Female flowers :—The surface colour of the peduncle is visible here at the inter-spaces left uncovered by the rather thin spreading of these female flowers all over the surface. The colour of the surface of the peduncle as well as of the female flowers is dirty brown and so the whole of this portion is brown in appearence. These female flowers consist of only the carpels and there is no perianth. Carpels are flexible and more or less bent; stigma is 3-to 4-lobed. Three lobed stigmas are common. Each lobe is conoid and its surface is warty. The ovary is 3 to 4-cornered.



Ovules :—If the ovary is cut transversely we get 3 to 4 loculi according to the number of stigmatic lobes, which are either 3 or 4. So far as it was seen there was only one ovoid ovule per loculus.

Tendency of the unisexual flowers to become hermaphrodite :—In this specimen of the inflorescence there was one flower in which there was one carpel surrounded by four yellow anthers. And this flower was situated at the junction of the male and female flower bands.

To a distant observer this inflorescence (with the spathe removed) appears to resemble a large fungus.

MISCELLANEOUS NOTES.

Pyrenacantha volubilis Hook.

On page 125 of Vol. I of the *Journal of Indian Botany* is a note on the above species and its distribution. The following observations extend its habitat.

Apparently at the time Vol. I of the Flora of British India was published this species was unknown in India and had only been recorded in Ceylon. Besides the areas noted in the note referred to above I have seen this plant in the following localities in the Madras Presidency :—

In the Nellore District, close to the coast and at about sea level and also in the interior of the district. In the Tinnevelly District and in the Coimbatore District both in the dry South East portion and in the North Central.

The elevations at which I have seen it lie between practically sea level and 1,000 feet. It is typically a plant of dry and almost arid climates.

I have found the flowers in February, September, November and December and the ripe fruit in November and December.

The vernacular names I have been able to ascertain are :—

Telugu (Nellore) *Porapotri* ; Tamil *Ala-kodi* (Madura) and *Karungali* (North-centre of Coimbatore).

C. E. C. FISCHER.

Scoparia dulcis Linn.

Sir J. D. Hooker wrote in 1885 (Flora of British India, Vol. IV, p. 29) of this little plant :—" Though now a superabundant Bengal plant according to Mr. Clarke, it was unknown in Roxburgh's time and occurs in no Indian Herbarium except Clarke's. Voigt mentions it (1845) as found about Serampore, whence probably it has spread quite recently."

T. Cooke (Flora of the Presidency of Bombay, Vol. II, p. 310) writes in about 1908 :—" This weed, a native of Tropical America, is becoming naturalised in many parts of India, notably in Bengal. Woodrow reports having found it in a salt swamp near Bombay, flowering in November. I have not seen his specimens."

It would seem that this plant has been introduced, therefore into India within the past 100 years certainly, possibly within 80 years.

It would appear that it was rare, if found at all, outside Bengal so late as 1885, and rare in Bombay even up to 1908. It would be interesting to be able to trace its spread from Serampore and its rate of progress. In this light the notes of my own observation below may be of interest.

I first became acquainted with the species in the district of Ganjam in about 1900. That district borders on Orissa. Prain gives its distribution for Bengal (Bengal Plants, p. 772) in about 1903 as " in every province."

I have also seen it in the following places in the Madras Presidency :—Practically throughout Malabar, in the Nilgiri Wynaad, in the Central and South-West portions of Coimbatore and in the portions of the Cochin State adjoining the latter district. In all these localities, all of which are fairly to extremely damp, it grows vigorously and in abundance. The elevations at which it is found in these parts ranges from practically sea level to about 3,000 feet. The flowering and fruiting I have noticed as at any time from May to February *i.e.*, at any season but the very driest.

Perhaps other readers would record their observations in other localities giving elevations, dates of flowering and also some idea of the nature of the locality. Such notes would be specially interesting from the Bombay Presidency.

C. E. C. Fischer.

CURRENT LITERATURE.

Arber, Agnes. The Leaves of the Irids and the Phyllode Theory.—*A paper read before Sect. K of the Brit. Ass. Adv. Sci. August, 1920.*

In this paper an attempt is made to apply the Phyllode Theory—considered by the author in a previous general memoir (Annals of Botany, Vol. 32, 1918, p. 465), to the special case of the Iridaceae. The peculiar character of the leaf of the *Iris* has been recognised from time immemorial and its interpretation has given rise to much controversy. For this and other Irids the writer rejects the view that the limb is produced by congenital concrescence of the two halves of the sheath; she considers that the clue to its interpretation is to be found in the comparison with the phyllodes of *Acacia*. This parallelism is traced in some detail. It is shown, for instance, that the leaf of *Iris Douglasiana* closely resembles the phyllode of *Acacia pendula*, while, in the same way *Gladiolus dracocephalus* can be compared with *A. Uncinella; Sisyrinchium junceum*, with *A. teretifolia*; and the four-angled leaf of *Gladiolus ornatus* with *A. incurva*. The author regards

the comparison with *Acacia* phyllodes as indicating that the simpler types of Irid leaf are petiolar phyllodes. She has further come to the conclusion that the same explanation applies to the more complex types of leaf met with in the family, since these prove on examination to be readily derivable from the simpler types, among which the ensiform leaf is regarded as fundamental.

The writer considers that leaf-evolution within the family has proceeded on two distinct lines; on one line the essential feature has been the reduction and ultimately the complete loss of the petiolar region of the phyllode; on the other line this region, instead of being lost, has been developed and elaborated.

Moraea Sisyrinchium may be taken as an example of the cases in which reduction of the petiole plays the chief role. The greater part of the leaf is flat and dorsiventral, but it ends in a short cylindrical apex, interpreted as a vestigial petiole, while the leaf base forms the main part of the leaf.

The second line of progression from the simpler types—that of the elaboration of the petiolar region—leads us to the more peculiar leaves among the Iridaceae, some of which are so anomalous that it requires a considerable effort to realise that they are leaves at all. The leaf of *Gladiolus tristis*, for instance, is cruciform in transverse section, while that of *Cypella* is of an even stranger type, and looks as if it were elaborately folded. The clue to the peculiarities of both these leaves is to be found in the transition from leaf-sheath to limb. In both cases the study of the extreme base of the limb suggests that it is a cylindrical petiolar phyllode, modified, however, by invaginations and keels. It is the extreme point to which this invagination is carried which is the main factor in the production of these aberrant leaf-types.

The writer's examination of the leaves belonging to the two main tribes of the Iridaceae (Iridoideae and Ixioideae) has led her to the conclusion that they can all be explained as phyllodes variously modified from the ensiform type. The third tribe, the Crocoideae, presents at first sight rather more difficulty. But, in this case also, the study of the transition from sheath to limb reveals the fact that we are dealing with a petiolar phyllode. The leaf of *Crocus* itself is a very peculiar one, and has hitherto been regarded as entirely isolated, and as showing no morphological relation with any other type in the family. But when the *Crocus* leaf is considered in the light of the Phyllode Theory, it at once falls into line with those of other plants belonging to the tribe. The writer interprets it as a petiolar phyllode modified by paired invaginations, and regards its resemblance to an ordinary bifacial blade as purely superficial.

The members of the Iridaceae have all had the same problem to solve—that of how to transform a petiolar phyllode into something with a more adequate assimilating surface—and they have apparently discovered only two methods by which to achieve it, namely invagination and the development of keels and wings. But the varying way in which they have applied these monotonous methods has resulted in the evolution of an astonishing variety of "pseudo-laminae."

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THE PHYSIOLOGICAL ANATOMY OF THE PLANTS OF THE INDIAN DESERT

BY

T. S. SABNIS, B.A., M.Sc.,
St. Xavier's College, Bombay.

(*Continued from p. 13.*)

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BORAGINACEAE

Ehretia aspera *R.*—Figs. 202, 203. Woody. Mesophyll isobilateral. Veins provided with bundle-sheath. Tanniniferous secretions in the sheath cells and in cells of the middle tissue. Hairs unicellular and with verrucose walls. Pericycle of large groups of stone-cells. Bast fibres in soft bast. Pith of cells with lignified walls. Solitary crystals in some of the pith cells.

Heliotropium supinum *L.*—Fig. 204. Herbaceous. Mesophyll of palisade tissue on the upper side and of arm-palisade tissue on the lower. Veins provided with bundle-sheaths. Hairs unicellular and with verrucose walls. Middle tissue absent. Pericycle of groups of bast fibres. Pith of thin-walled cells.

Heliotropium rariflorum *Stks.*—Figs. 205, 206, 207, 208, 209, 211. Woody. Mesophyll isobilateral. Veins provided with bundle-sheaths. Bundle-sheath cells and cells of the middle tissue with tanniniferous contents. Pericycle of groups of stone-cells. Pith of cells with lignified walls. Some of the pith cells with solitary crystals.

Heliotropium undulatum *Woodr.*—Figs. 212, 213, 214 Woody. Mesophyll isobilateral. Middle tissue present. Clustered crystals in the mesophyll. Trichomes with terminal cell curved and

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with verrucose walls. Pericycle of groups of stone-cells. Pith of thin-walled cells.

Heliotropium paniculatum *L.*—Figs. 215, 216. Woody. Mesophyll formed of palisade tissue on the upper side and of arm-palisade tissue on the lower. Middle tissue present. Hairs unicellular and with verrucose walls. A layer of colourless tabular cells on the inner side of the assimilatory tissue in the axis. Endodermis with granular contents. Pericycle formed of groups of stone-cells. Pith of thin-walled cells with granular contents.

Tricodesma indicum *Br.*—Figs. 217, 218. Quite herbaceous. Mesophyll formed of palisade tissue on the upper side and of arm-palisade tissue on the lower. Veins with bundle-sheaths. Middle tissue absent. Sclerenchymatous pericycle not developed. Pith of thin-walled cells.

Sericostoma pauciflorum *Stks.*—Figs. 219, 220. Woody. Mesophyll isobilateral. Middle tissue present. Hairs unicellular and with verrucose walls. Pericycle forming a composite ring of stone-cells. A layer of colourless tabular cells on the inner side of the assimilatory tissue in the axis. Pith of thin-walled cells.

Arnebia hispidissima *DC.*—Figs. 221, 222, 223. Herbaceous. Mesophyll formed of palisade tissue on the upper side and of arm-palisade tissue on the lower. Middle tissue absent. Veins with bundle-sheaths. Hairs unicellular and with verrucose walls. Pericycle formed of isolated stone-cells. Pith of cells with lignified walls.

Structure of the Leaf.—The epidermal cells have the outer walls greatly thickened. The inner walls are thin and more or less undulated. The outer walls are muriculate in *E. aspera* and *A. hispidissima*; they are convexly arched outwards in *T. indicum* and *S. pauciflorum*. Some of the epidermal cells in *H. rariflorum* and *T. indicum* are vertically elongated, while the rest are tabular or polygonal; this peculiarity in shape may be supposed to mark the commencement of unicellular hairs (fig. 206.) These hairs have been observed at different stages of development (fig. 206, 207, 208). It seems that the epidermal cells at these spots divide by vertical walls; the daughter cells then elongate and present a shape as in (figs. 210, 217). One of these daughter cells then elongates still more and gives rise to a small unicellular hair with a large lumen and with a broad base. These hairs will be discussed in greater detail under the hairy covering. The stomata are usually placed in depressions produced either by the thickened or papillose outer epidermal cells. The guard-cells are in the plane of the surrounding cells. The stomata are more numerous in members with a larger number of veins. In *H. paniculatum* there is a sort of depression produced by the downwardly pro-

jecting mid-rib and by the downwardly curved margins. In this portion stomata as well as hair-like epidermal cells are more numerous than on the upper surface. The stomata are thus protected from direct sun light and transpiration is very much checked.

The mesophyll is isobilateral in *E. aspera*, *H. rariflorum*, *H. undulatum* and *S. pauciflorum;* in *E. aspera* palisade cells on the upper side are much longer than those on the lower. It consists of palisade tissue on the upper side and of arm-palisade tissue on the lower in *H. supinum*, *H. paniculatum*, *T. indicum* and *A. hispidissima*. There is a tissue of large thin-walled colourless polygonal cells in the middle of the mesophyll of all members except *H. supinum*, *T. indicum* and *A. hispidissima*. This tissue, which may be termed the middle tissue, seems to partake in the formation of bundle-sheaths. The cells of the middle tissue may hold clustered crystals, or tanniniferous contents, or they may serve occassionally as water-reservoirs.

Internal secretory organs are represented by tannin sacs confined to the middle tissue of the mesophyll, or to the bundle-sheaths. The cells of the middle tissue as well as those of the bundle-sheaths in *H. rariflorum* and *E. aspera* hold tanniniferous contents which are confined only to the sheath-cells, or to the cells of the middle tissue in *H. paniculatum* and *H. undulatum* respectively.

Oxalate of lime is present in the form of clustered crystals in groups of cells between the middle tissue and epidermis on either side in *H. undulatum* (fig. 212). Solitary crystals are found in the pith cells of *E. aspera* and *H. rariflorum*.

Calcium carbonate is deposited either in the outer epidermal walls as in *H. supinum* or in walls of clothing hairs as in other members. Deposits of calcium carbonate give a warty appearance to the surface of the leaf or to the walls of the hairs, and they are the cause of roughness of the leaf and of the axis.

The veins are embedded in all members except in *E. aspera* in which they are vertically transcurrent above and below by sclerenchyma. Bundle-sheaths occur round the veins in *E. aspera*, *H. supinum*, *H. rariflorum*, *T. indicum* and *A. hispidissima*. The veins of the mid-rib are protected by thin-walled collenchyma which surrounds them. The vascular bundles are bicollateral in *H. paniculatum*. The veins are numerous in all members except in herbaceous members, viz: *H. supinum*, *T. indicum* and *A. hispidissima*. They anastomose freely and are prominent either on both the surfaces as in *H. rariflorum* or only on the lower surface as in *E. aspera* and *H. undulatum*. The veins of the mid-rib are prominent on the lower side in all the members. Upper surface of the mid-rib is grooved in *S. pauciflorum*.

The scantiness of the veins is characteristic of leaves of herbaceous members, while their abundance and anastomosis distinguish the leaves of woody members. Though the veins are numerous in the latter, transpiration is arrested by the thickened and cuticularised outer epidermal walls, by the poorly developed ventilating system and by the abundance of tannin in cells of the mesophyll.

The clothing hairs on the leaf and axis in all members except *H. supinum* are characterised by calcification of their walls which are consequently verrucose and rough. Some of the epidermal cells in these members undergo a division by vertical walls as in (fig. 210) and elongate as shown in (figs. 207, 208, 209). The walls of the terminal portion are secondarily impregnated with calcium carbonate. The hairs thus formed are unicellular, conical and have a broad thin-walled base. They are found in the leaf and axis of all members except *H. supinum*. Besides these, there are found other forms of clothing hairs in the different members. In *E. aspera* (fig. 202), *T. indicum* (fig. 218) and *A. hispidissima* (figs. 221, 222, 223) are found unicellular hairs which have a thin-walled bulbous base and a tapering terminal portion with walls, verrucose or smooth as in *H. supinum*. Hairs in *H. undulatum* consist of a thin-walled basal cell and of a long appressed terminal cell with verrucose walls. Cystolith-like structures occur in the basal portions of the hairs of *S. pauciflorum*, *A. hispidissima*, *H. rariflorum* and *H. undulatum*, *T. indicum*.

It should be observed in all these forms of hairs that the basal portion is bulbous and thin-walled and it may be a means of absorbing water trickling down the terminal portion. Hairs, when not numerous, are more or less appressed as in *E. aspera* and *H. undulatum* and they form a suitable light screen.

Glandular hairs are not common. They are found in a very small number in *H. supinum*, and they consist of a stalk-cell and of a spherical unicellular head.

Structure of the Axis:—The epidermal cells have outer walls thickened and cuticularised in all members except the herbaceous ones. The lateral walls are usually thin and undulated. Some of the epidermal cells in *T. indicum* and *S. pauciflorum* are large and vertically elongated (figs. 217, 220); and give rise to a somewhat ribbed appearance to the axis. These cells may have the function of giving rigidity to the epidermal tissue. The primary cortex is generally characterised by an assimilatory tissue which consists either of palisade cells as in *H. undulatum* (fig. 214), or of arm-palisade tissue as in *S. pauciflorum* (fig. 220) and *A. hispidissima*, or of chlorenchyma as in *E. Aspera*, *H. supinum*, *H. paniculatum* (fig. 216) and *T. indicum*. There is a two-layered tissue of large thin-walled, colourless tabular

Structure of wood :—

Name of species.	Vessels.			Interfascicular wood prosenchyma.		Medullary Rays.		General Remarks.
	Size.	Abundance.	Arrangement.	Size of lumen.	Abundance.	Size.	Abundance.	
E. aspera ...	Large.	Few ...	Incomplete.	Small.	Extensive.	1-2 seriate.	Numerous ...	Rows of vessels sometimes found in groups.
H. supinum ...	,,	Numerous.	Not quite in rows.	Very large.	Scanty.	,,	,, ...	
H. rariflorum ...	Small.	Few ...	Incomplete rows.	Very small.	Extensive.	1 seriate.	,, ...	
H. undulatum ...	Large.	,, ...	,,	Large.	,,	,,	,, ...	
H. paniculatum ...	Small.	,, ...	,,	Small.	,,	,,	,, ...	
S. pauciflorum ...	,,	,, ...	,,	,,	,,	,,	Few ...	
A. hispidissima ...	Large.	Numerous.	,,	Large.	Scanty.	,,	Numerous ...	Vessels more numerous in the inner half.

cells below the assimilatory tissue in *H. paniculatum* (fig. 216) and *S. pauciflorum*; it may form a water storing tissue. *E. aspera* possesses some thick-walled ovoid cells in the assimilatory tissue which may be of the nature of secretory cells. Cork is well developed and is subepidermal in *E. aspera*. The endodermis is not differentiated except in *H. paniculatum* in which it is characterised by granular contents.

The pericycle forms a composite ring of stone-cells in *S. pauciflorum*; it is composed of closely placed groups of stone-cells in *E. aspera*, *H. rariflorum*, *H. paniculatum* and *H. undulatum*. It consists of isolated stone-cells in *A. hispidissima* and of groups of bast fibres in *H. supinum*. A sclerenchymatous pericycle is not developed in *T. indicum*, which is quite herbaceous. There are large groups of bast fibres in the soft bast of *E. aspera*.

The wood forms a composite ring in all members. The perforations of the vessels are simple. It should be observed that in herbaceous members vessels are large and numerous in correspondence with more vigorous transpiration. The development of interfascicular wood prosenchyma is in inverse proportion to the size and abundance of the vessels. The abundance of medullary rays usually corresponds with that of vessels. Some of the vessels towards the pith are found to hold tanniniferous contents. The pith consists of small cells with lignified walls in *E. aspera*, *H. rariflorum* and *A. hispidissima*; in other members it is formed of very thin-walled cells. The pith cells of *H. paniculatum* hold granular contents. The pith is strengthened by sieve-sclereids in *H. rariflorum* (fig. 211 SV).

CONVOLVULACEAE.

Cressa cretica *L.*—Figs. 224, 225. Guard-cells in the same plane. Front cavity in depression produced by outer thickened epidermal walls. Mesophyll isobilateral. Internal secretory organs and oxalate of lime absent. Veins provided with green bundle-sheaths. Clothing hairs two-armed. Glandular hairs horizontal. Pericycle formed of closely placed groups of stone-cells. Assimilatory tissue in the axis formed of palisade cells. Wood composite. Pith of thin-walled cells.

Breweria latifolia *Bth.*—Figs. 226, 227. Guard-cells on the same plane. Front cavity placed in depression formed by outer thickened epidermal walls. Mesophyll isobilateral. Internal glands in the form of colourless secretory cells surrounded by specialised subsidiary cells in the mesophyll. Clustered crystals near veins, in cortex and pith. Solitary crystals in outer soft bast. Veins provided

with green bundle-sheaths. Larger veins vertically transcurrent. Clothing hairs two-armed. Glandular hairs absent. Pericycle formed of isolated stone-cells and of very small stone-cell groups. Assimilatory tissue in the axis formed of chlorenchyma. Wood composite. Pith of thick-walled cells.

Convolvulus microphyllus *Sieb.*—Figs. 228, 229. Guard-cells elevated. Front cavity placed in a depression formed by outer thickened epidermal walls. Mesophyll isobilateral. Veins embedded and provided with green bundle-sheaths. Internal glands and oxalate of lime absent. Terminal cell of the clothing hairs seated obliquely on the stalk cell. External glands spherical on the leaf and club-shaped on the axis. Pericycle formed of thin long groups of stone-cells. Assimilatory tissue in the axis formed of palisade cells. Wood composite and narrowed on two opposite sides. Pith of thin-walled cells.

Convolvulus glomeratus *Chois.*—Fig. 230. Guard-cells elevated. Front cavity on a level with the surface. Mesophyll of palisade tissue on the adaxial side and of arm-palisade tissue on the abaxial side. Secretory cells with surrounding subsidiary cells present. Oxalate of lime absent. Veins embedded and without bundle-sheaths. Clothing hairs with terminal cell vertically placed on the stalk cell. External glands club-shaped. Assimilatory tissue in the axis parenchymatous. Pericycle of closely placed thin long groups of stone-cells. Wood composite and narrowed on two opposite sides. Pith of thin-walled cells.

Ipomoea sindica *Stapf.*—Figs. 231, 232, 233, 234, 235. Guard-cells elevated. Front cavity on a level with the surface. Mesophyll of palisade tissue on the adaxial side and of arm-palisade tissue on the abaxial side. Internal glands absent in the leaf and found in the axis in the form of secretory cells with tanniniferous contents. Oxalate of lime absent. Terminal cell of clothing hairs superficially knobbed and seated vertically on the stalk-cell which is placed on an epidermal cell in the leaf and on a multicellular pedestal on the axis. External glands horizontal. Assimilatory tissue in the axis parenchymatous. Wood composite and narrowed on two opposite sides. Pericycle forming a composite ring of stone-cells. Pith of thin-walled cells with granular contents.

Structure of the Leaf:—The epidermis consists of tabular cells with the outer walls thickened and convexly arched outwards; inner walls are also thickened. The lateral walls are thin and straight. The cuticle is thin and striated.

The stomata are developed equally on both the surfaces of isobilateral leaves; they are more numerous on the lower surface of

bifacial leaves of *C. glomeratus* and *I. sindica*. Guard-cells are elevated in *C. microphyllus* (fig. 228), *C. glomeratus* and *I. sindica* (figs. 231, 232); they are placed in the plane of surrounding cells in other members. The guard-cells are accompanied by subsidiary cells except in *C. cretica*. The front cavity is on a level with the surface in *C. glomeratus* and *I. sindica* (fig. 233); in other members it is placed in a depression formed by thickened outer epidermal walls. The elevated position of the guard-cells may be due to the occurrence of a dense protective covering of clothing hairs.

The mesophyll is isobilateral (fig. 228) in all members except *C. glomeratus* and *I. sindica* (fig. 231), in which it consists of palisade tissue on the adaxial side and of arm-palisade tissue on the abaxial side.

Internal secretory organs occur in the form of secretory cells in the middle of the mesophyll of *B. latifolia* and *C. glomeratus* and in cortex and pith of *I. sindica* (fig. 234 G). In *B. latifolia* and *C. glomeratus* they consist of colourless secretory cells with surrounding arm-palisade cells differentiated into subsidiary cells. Secretory cells in *I. sindica* are greatly horizontally elongated and hold tanniniferous contents.

Oxalate of lime occurs in the form of clustered crystals in the neighbourhood of veins and in the cortex and pith, and in the form of solitary crystals in the soft bast of *B. latifolia*. In other members oxalate of lime is not found.

The veins are embedded except some of the larger ones in *B. latifolia* which are vertically transcurrent above and below by collen. chyma. The veins in *C. cretica*, *B. latifolia* and *C. microphyllus* (fig. 228) are provided with green bundle-sheaths. Vascular bundles of the veins are bicollateral.

Hairy covering consists of clothing and glandular hairs. Clothing hairs are composed of a terminal cell of variable shape and of a stalk-cell seated either upon a single epidermal cell, or on two epidermal cells formed by a vertical wall (fig. 231), or on a multicellular pedestal of epidermal cells (fig 235).

The terminal cell is simple and is seated straight upon the stalk-cell in *C. glomeratus* (fig. 230) or seated obliquely on the stalk-cell in *C. microphyllus* (fig. 228). In *I. sindica* the stalk-cell of clothing hairs on the leaf is placed vertically on a single epidermal cell or on two epidermal cells formed by a vertical division wall (fig. 231); the stalk-cell on the axis is seated vertically on a multicellular pedestal of epidermal cells (fig. 235). The terminal cell bears minute solid knobs on the surface.

In *C. cretica* (figs. 224, 225) and *B. latifolia* (fig. 226), the terminal cell is two-armed; arms are of uniequal length and are horizontally

placed. The stalk-cell is cylindrical. On the axis of *C. microphyllus* there are large cells, bearing clothing hairs intercalated amongst epidermal cells of ordinary dimensions.

The glandular hairs are placed in epidermal depressions and consist of an unicellular stalk-cell seated upon an epidermal cell which is much depressed and of a head. The head is either club-shaped and divided by horizontal walls as in. *C. cretica* (fig. 224) and *C. glomeratus*, or spherical and divided both by horizontal and vertical walls as in *C. microphyllus* (fig. 228), or flat and divided by horizontal walls as in *I. sindica* (fig. 231)

The lower cells of the head of club-shaped glands are also vertically divided (fig. 224). The walls of external glands with spherical heads are very thin. External glands seem to be absent in. *B. latifolia*.

Clothing hairs as well as external glands are less numerous on the axis than on the leaf. This is due to the expanded surface of the latter which is more exposed to direct rays of the sun.

Structure of the Axis.—The epidermis consists of tabular cells with outer and inner walls thickened and convexly arched outwards and inwards respectively. The lateral walls undulated in *C. cretica* and *C. glomeratus*. In *C. microphyllus* large pyramidal cells are intercalated amongst epidermal cells of ordinary dimensions and usually bear clothing hairs. The cuticle is striated. The primary cortex is characterised by the presence of assimilatory tissue formed either of palisade cells as in *C. cretica* (fig. 225) and *C. microphyllus* (fig. 229) or of chlorenchyma as in other members (fig. 234).

The pericycle in *C. cretica* and in both the species of *Convolvulus* is composed of closely placed long thin groups of stone-cells; in *I. sindica* it forms a composite ring of stone-cells. In *B. latifolia* the pericycle consists partly of isolated stone-cells and partly of very small stone-cell groups. It undergoes reduction on a small portion of the lower side of the inclined axis of *C. cretica*, where it consists of a few isolated stone-cells. A well developed sclerenchymatous pericycle is necessary on the upper side of the inclined axis to prevent the axis from bending.

The wood is composite. The vessels have simple perforations and the medullary rays are uniseriate. The vessels are numerous and are arranged in rows in *C. cretica* (fig. 225), *C. glomeratus* and *I. sindica* (fig. 234); in other members the vessels are few. The abundance of interfascicular wood prosenchyma is inversely proportional to that of vessels.

In both the species of *Convolvulus* and in *I. sindica* small portions on diametrically opposite sides of the wood-ring are much narrowed

and possess a few small vessels. The wood-ring in *C. cretica* is much narrowed on one side where there are a few small vessels.

These modifications in the structure of wood may be due to the influence of the direction of the prevailing wind in the first case, and to the inclined position of the axis in the second case. The reduction of wood, accompanied also by reduction of the sclerenchymatous pericycle in *C. cretica*, takes place on those sides of the axis which are less affected by the prevailing wind and on the lower side of the inclined axis which is less exposed to the sun and wind and possess consequently less functional activity.

Vascular bundles in all members are bicollateral and there are two rings of soft-bast, one on the outer side and another on the inner side of the wood-ring.

The pith consists of thin-walled cells in all members except in *B. latifolia* where it consists of cells with thickened and lignified walls. The pith cells in *I. sindica* are mostly filled with granular contents.

General Review.— The epidermal cells are not much thick-walled ; but have the outer and inner walls convexly arched outwards and inwards respectively. The guard-cells are elevated and are associated with subsidiary cells. The mesophyll is either isobilateral or is composed of palisade tissue on the upper side and of arm-palisade tissue on the lower. Internal glands, when present, consist of colourless secretory cells with surrounding subsidiary cells or of secretory cells with tanniniferous contents. Veins are embedded with the exception of some of the larger veins which are vertically transcurrent ; they may or may not be provided with bundle-sheaths. Oxalate of lime occurs in the form of clustered or solitary crystals, or it may not be found.

The clothing hairs are composed of a stalk-cell, seated upon a single epidermal cell or on a pedestal and of a terminal cell which may be simple and placed vertically or obliquely on the stalk-cell, or which may be two-armed. External glands are placed in epidermal depressions and are composed of a stalk-cell and of a head which may be club-shaped, spherical or horizontal. The head may be divided only by horizontal or vertical walls or by both.

The assimilatory tissue in the axis is composed of palisade cells or of chlorenchyma. The pericycle either forms a composite ring of stone-cells, or is formed either of large groups of stone-cells or of isolated stone-cells. Vascular bundles are bicollateral and the wood is composite. Interfascicular wood prosenchyma is not abundant and medullary rays are uniseriate. The wood as well as the pericycle undergo modifications due to differences in functional activity in dif-

ferent portions of the axis which are not equally affected by the sun and wind. The pith consists of thin-walled cells or of cells with thickened and lignified walls.

SOLANAGEAE.

Solanum incanum *L.* — Figs. 241, 242, 243, 244. Mesophyll bifacial. Oxalate of lime found in the form of crystal sand in mesophyll, cortex, soft-bast, intraxylary phloem and pith. Clothing hairs tufted. Epidermis one layered. Cork subepidermal. Collenchyma developed below cork. Pericycle forming a loose ring of bast fibres. Vessels arranged in bundles connected by strands of interfascicular wood prosenchyma.

Solanum albicaule *Kotsc.*—Figs. 236, 237, 238. Mesophyll isobilateral. Oxalate of lime found in the form of crystal sand in mesophyll and pith. Clothing hairs tufted and uniseriate trichomes. Epidermis of the axis three layered. Collenchyma subepidermal. Vessels few and uniformly distributed in the wood-ring. Intraxylary phloem present.

Lycium barbarum *L.*—Fig. 239. Mesophyll isobilateral. Oxalate of lime found in the form of crystal sand in mesophyll of the leaf and epidermis, soft bast and pith of the axis. Clothing hairs absent. Epidermis of the axis one-layered and with outer walls thickened and muriculate. Sclerenchymatous pericycle not developed. Cork subepidermal and characterised by isolated stone-cells. Vessels few and uniformly distributed in the wood-ring. Intraxylary phloem present.

Structure of the Leaf :—The epidermal cells are tabular with the outer walls thickened and convexly arched outwards. The lateral walls are thin and undulated. The outer walls in *L. barbarum* (fig. 239) are muriculate. The upper epidermal cells are mostly filled with crystal sand.

The stomata are equally numerous on both the surfaces of isobilateral leaves, while they are more numerous on the lower surface of bifacial leaves. The front cavity is placed in a depression formed by outer thickened epidermal walls. The guard-cells are accompanied by ordinary epidermal cells.

The mesophyll is isobilateral in *S. albicaule* and *L. barbarum* and is bifacial in *S. incanum*. Some of the palisade cells contain crystal sand.

Oxalate of lime occurs in the form of crystal sand in all members. Cells filled with crystal sand are found abundantly in the mesophyll of the leaf and in the epidermis of the axis of *L. barbarum*,

Cells with crystal sand occur in medullary rays and outer soft bast of *S. incanum* and *L. barbarum*. Crystal sand occurs abundantly in cortex and inner soft bast of *S. incanum*. The abundance of oxalate of lime in the leaf and axis gives an acrid taste to the tissues of the plants and prevents them from being easily devoured by animals.

Veins are embedded and are not provided with bundle-sheaths.

The hairy covering consists of clothing and glandular hairs. The clothing hairs on the leaf and axis of both the species of *Solanum* are tufted. They consist, in *S. albicaule*, of a short biseriate stalk and of a tuft of ray-cells, some of the rays being uniseriate (fig. 236). In *S. incanum* (fig. 242), the stalk is multiseriate and is usually longer on the axis. In addition to the tufted hairs in *S. albicaule*, there are uniseriate trichomes (fig. 238). Clothing hairs are absent in *L. barbarum*.

Glandular hairs occur in leaf and axis of *L. barbarum* and of both the species of *Solanum*; and are composed of a short uniseriate stalk and of an ellipsoidal head which is irregularly divided (fig. 237).

Structure of the Axis.—The epidermis consists of a single layer of tabular cells with the outer walls greatly thickened and convexly arched outwards in *S. incanum* and *L. barbarum*. The epidermis in *S. albicaule* is composed of more than one layer (three layers in the specimen examined) of vertically tabular cells which are uniformly thickened a little on all sides. The epidermal cells of *L. barbarum* are mostly filled with crystal sand. The cortex in *S. incanum*, and *L. barbarum* is characterised by cork which is subepidermal. Cork in *L. barbarum* is strengthened by isolated stone-cells. The collenchyma is subepidermal as in *S. albicaule*, or it occurs below the cork as in other members. In *S. incanum* collenchyma is extensive and the inner portion of the cortex consist of large polygonal cells, some of which are filled with crystal sand.

The pericycle forms a loose ring of bast fibres in both the species of *Solanum*. Scleranchymatous pericycle is not developed in *L. barbarum*.

The wood is composite in all members. Medullary rays are uniseriate and numerous. The vessels are few and large and are uniformly distributed in rows in the wood ring of *S. albicaule* and *L. barbarum*; interfascicular wood prosenchyma is extensive and consists of cells with thickened walls and with small lumen. In *S. incanum* the vessels are large and are arranged in bundles which are connected by strands of interfascicular wood prosenchyma, formed of cells with thin walls and large lumen. The wood-ring in *S. incanum* is narrowed in a small portion on one side where it consists of a few vessels and of extensive connecting strands of interfasci-

cular wood-prosenchyma. This narrowed portion of the wood-ring represent the lower side of the inclined axis where the functional activity is comparatively much less. In addition to the normal zone of soft bast on the outer side of the wood-ring there are groups of intraxilary soft bast on its inner side. Intraxilary soft bast is protected on its inner side by groups stone-cells. The pith consists of thin-walled cells. Some of the pith cells contain crystal sand.

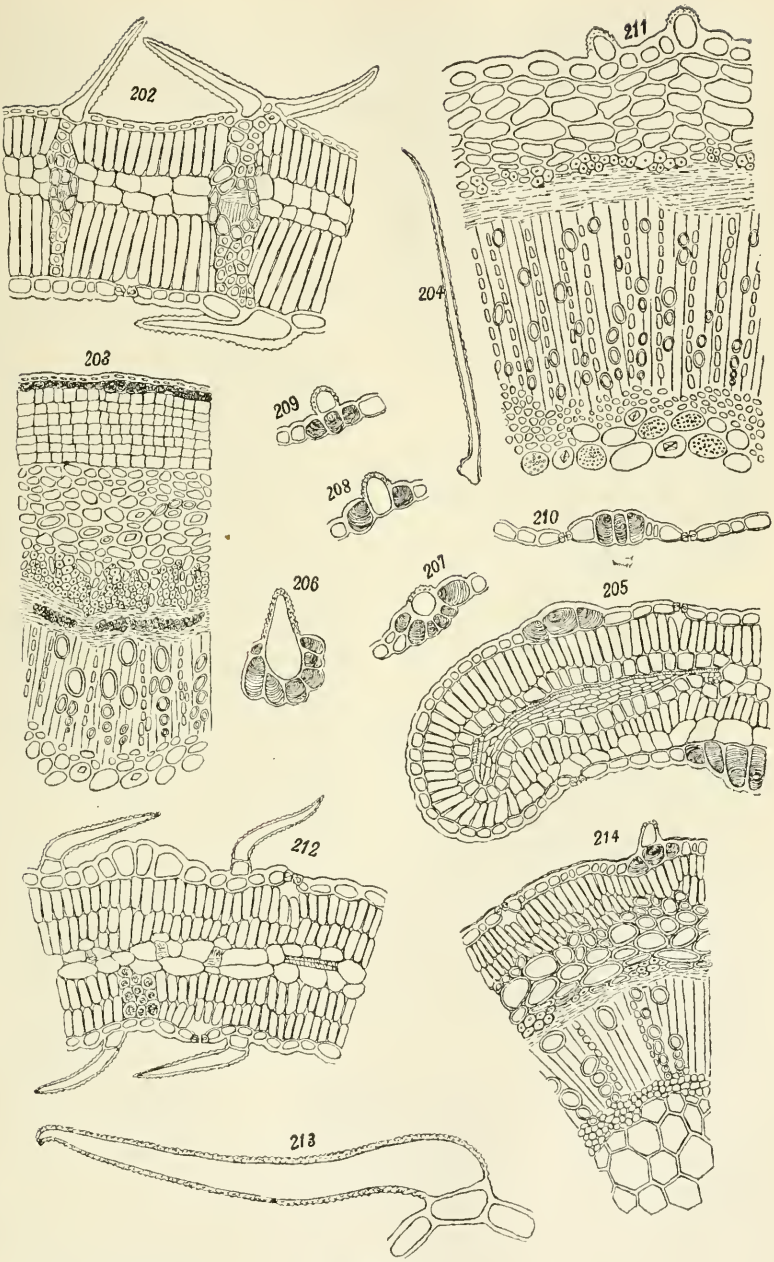
General Review :—The epidermal cells have their outer walls greatly thickened and cuticularised. The stomata are depressed and occur on both the surfaces ; they are surrounded by ordinary epidermal cells. The mesophyll is bifacial or is isobilateral. Oxalate of limo occurs abundantly in the form of crystal sand in the leaf and axis. The clothing hairs usually consist of a biseriate or multiseriate stalk and of a tuft of ray cells. In addition to the tufted hairs, uniseriate trichomes are found in *S. albicaule*. Glandular hairs are composed of a short uniseriate stalk and of an ellipsoidal head which is irregularly divided. The epidermis of the axis is one-layered or many-layered. The cork is sub-epidermal. The sclerenchymatous pericycle, when present, forms a loose ring of bast fibres. All the members are characterised by the occurrence of intraxilary soft bast. The vessels have simple perforations. The interfascicular wood prosenchyma is extensive. The medullary rays are uniseriate and numerous. Wood parenchyma is little developed. Pith consists of thin-walled cells.

(*To be continued.*)

Plate XXII.

202-203. *Ehretia aspera.*
202. T. S. of the leaf.
Oc. 6 Com.; Ob. 8 mm. Ap.
203. T. S. of the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.
204. *Heliotropium supinum.*
Hair on the leaf.
Oc. 2 Com.; Ob. 3 mm, Ap.
205-211. *Heliotropium rariflorum.*
205. T. S. of the leaf.
Oc. 4 Com.; Ob. 8 mm. Ap.
206, 207, 208, 209 Hair on the leaf in different stages of development.
Oc. 4 Com.; Ob. 8. mm. Ap.
210. T. S. of the leaf showing epidermis, stomata and cystolith-like structures.
Oc. 4 Com.; Ob. 8 mm. Ap.
211. T. S. of the axis.
Oc. 6 Com.; Ob. 8 mm. Ap.
212-214. *Heliotropium undulatum.*
212. T. S. of the leaf.
Oc. 6. Com.; Ob. 8 mm. Ap.
213. Hair on the leaf.
Oc. 8 Com.; Ob. 8 mm. Ap.
214. T S. of the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.

N.B.—To get the original dimensions multiply by 1·7.

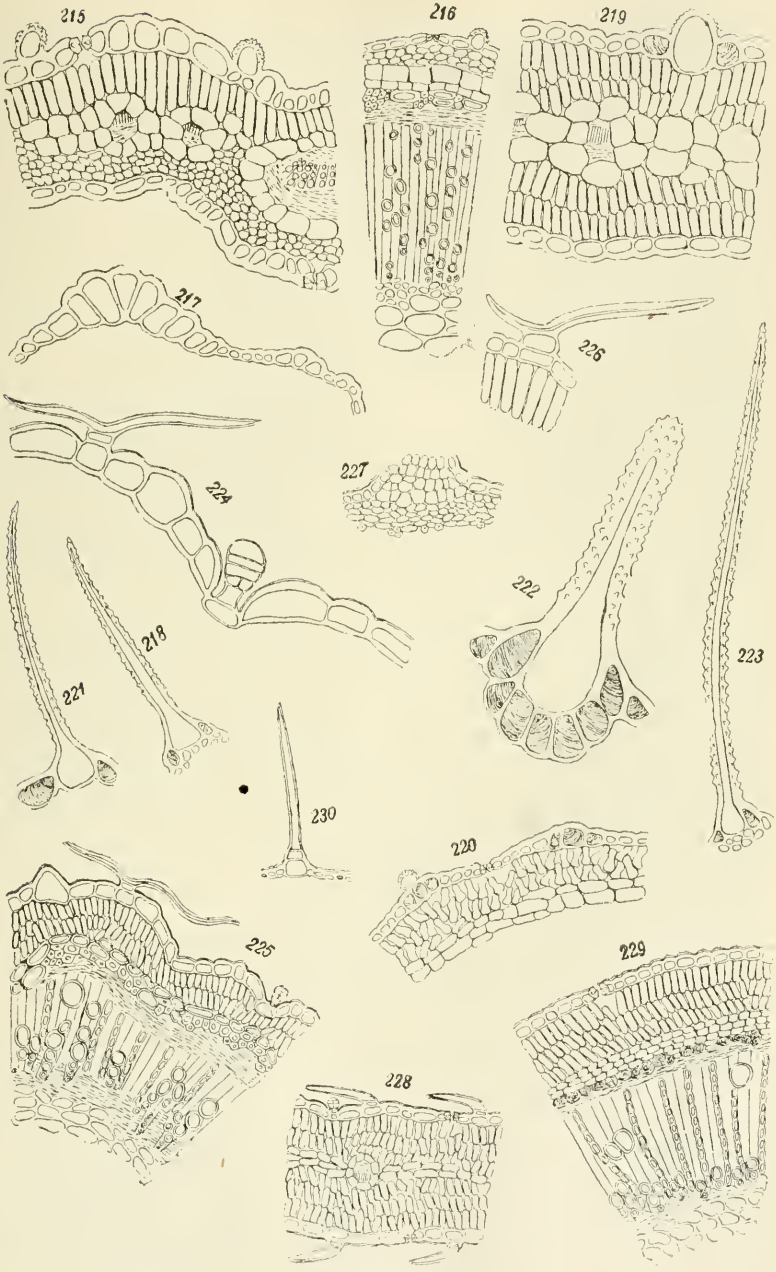


T. S. Sabnis del. PLATE XXII.

Plate XXIII.

215-216. *Heliotropium paniculatum.*
215. T. S. of the leaf.
Oc. 8 Com.; Ob. 8 mm. Ap.
216. T. S. of the axis.
Oc. 2 Com.; Ob. 3 mm. Ap.
217-218. *Trichodesma indicum.*
217. T. S. of the axis showing epidermis.
Oc. 6 Com.; Ob. 8 mm Ap.
218. Hair on the axis.
Oc. 2 Com.; Ob. 8 mm. Ap.
219-220. *Sericostoma pauciflorum.*
219. T. S. of the leaf.
Oc. 6 Com.; Ob. 8 mm. Ap.
220. T. S. of the axis showing epidermis, assimilatory tissue and cortical parenchyma.
Oc. 4 Com.; Ob. 8 mm. Ap.
221-223. *Arnebia hispidissima.*
221.
222. } Hair on the leaf.
Oc. 8 Com.; Ob. 8 mm. Ap.
223. Hair on the axis.
Oc. 2 Com.; Ob. 8 mm. Ap.
224-225. *Cressa cretica.*
224. T. S. of the leaf showing epidermis and hairs.
Oc. 4 Com.; Ob. 8 mm. Ap.
225. T. S. of the axis.
Oc. 6 Com.; Ob. 8 mm. Ap.
226-227. *Breweria latifolia.*
226. Hair on the leaf.
Oc. 4 Com.; Ob. 3 mm. Ap.
227. T. S. of the axis showing a lenticel.
Oc. 6 Com.; Ob. 8 mm. Ap.
228-229. *Convolvulus microphyllus.*
228. T. S. of the leaf.
Oc. 4 Com.; Ob. 8 mm. Ap.
229. T. S. of the axis.
Oc. 6 Com.; Ob. 8 mm Ap.
230. *Convolvulus glomeratus.*
Hair on the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.

N.B.—To get the original dimensions multiply by 1·7.

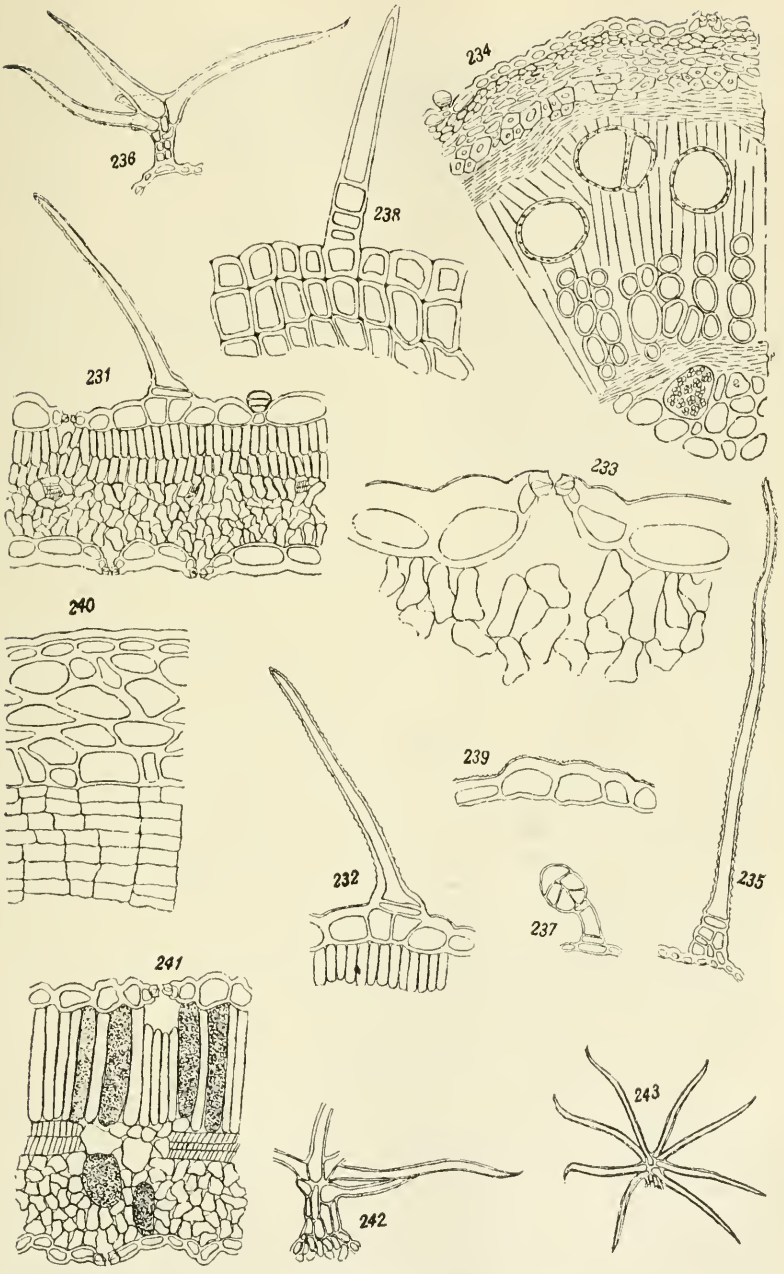


T. S. Sabnis del. PLATE XXIII.

Plate XXIV.

231-235. *Ipomoea sindica.*
231. T. S. of the leaf.
Oc. 6 Com.; Ob. 8 mm. Ap.
232. Hair on the leaf.
Oc. 8 Com.; Ob. 8 mm. Ap.
233. Stoma on the lower surface of the leaf.
Oc. 6 Com.; Ob. 3 mm. Ap.
234. T. S. of the axis.
Oc. 6 Com.; Ob. 8 mm. Ap.
235. Hair on the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.
236-238. *Solanum albicaule.*
236. Hair on the leaf.
Oc. 2 Com.; Ob. 3 mm. Ap.
237. Glandular hair on the leaf.
Oc. 4 Com.; Ob. 3 mm. Ap.
238. T. S. of the axis showing epidermis, hair and cork.
Oc. 4 Com.; Ob. 3 mm. Ap.
239-240. *Lycium barbarum.*
239. T. S. of the leaf showing epidermis.
Oc. 4 Com.; Ob. 3 mm. Ap.
240. T. S. of the axis showing epidermis, cortical parenchyma and cork.
Oc. 4 Com.; Ob. 3 mm. Ap.
241-243. *Solanum incanum.*
241. T. S. of the leaf.
Oc. 4 Com.; Ob. 3mm. Ap.
242. Hair on the leaf.
Oc. 4 Com.; Ob. 8 mm Ap.
243. Hair on the leaf.
Oc. 2 Com.; Ob. 8 mm. Ap.

N.B.—To get the original dimensions multiply by 1·7.



T. S. Sabnis del.

PLATE XXIV.

NOTES ON THE DISTRIBUTION OF LIVERWORTS IN THE WESTERN HIMALAYAS, LADAK AND KASHMIR.*

By Shiv Ram Kashyap,

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In January last the writer published a short paper on the distribution of Liverworts in the Western Himalayas. (Journal of Indian Botany, January, 1920). It was pointed out there that the number of Liverworts decreases as we pass from the east to the west horizontally, and the same law holds good in passing vertically upwards after a certain altitude, not only in the Outer Himalayan Range but also in the Middle and the Inner Ranges. It was also mentioned that beyond the Inner Himalayas there were no Liverworts in the region visited by the writer. The valley of Kashmir was not dealt with in this connection in that paper owing to the meagreness of collections at the writer's disposal.

Since then the writer has had the opportunity of travelling through a large part of the country beyond the Himalayas and of making more satisfactory observations on the distribution of Liverworts in Kashmir than he had been able to do before this. The route followed was after crossing the Himalayas was as follows :—From the Baralacha pass through Rupshu and across the Lachalung and Taghlang la passes to Leh, and from there, after travelling along the Indus for some distance, across the Fotu la, the Namyika la and lastly the Zoji la into the Kashmir valley, and ultimately after crossing the Banihal pass into the Punjab plain again.

It is proposed to give some more facts about the distribution of Liverworts observed during this journey.

The Outer and the Middle Himalayas.

In order to reach the Main Himalayan chain it was necessary to pass through a good deal of country already traversed by the writer on former occasions but the opportunity was taken of supplementing the observations made before. The exact path was from Dalhousie to Chamba, then up the Ravi for some distance in order to cross the Kugti pass (17,000 ft.) into Lahoul, and then up the Chenab to the Baralacha pass. The observations made before in this

* Read before the Indian Science Congress at Calcutta, February, 1921.

region were confirmed. The chief addition in the number of forms occurring near Dalhousie was the discovery of a *Porella* near Banikhet where it was found covering the trunks of some trees. It was also noted that the number of Liverworts was larger *below* Dalhousie than actually in its neighbourhood. The forms noticed between Chhatrari and Brahmaur were:—*Athalamia pinguis*, *Gollaniella pusilla*, *Grimaldia indica*, *Marchantia nepalensis*, *Pellia calycina*, *Porella* (25 species), *Radula sp.*, *Frullania sp. and Plagiochila sp.* Between Brahmaur and Kugti the following were met with:—*Athalamia pinguis*, *Fegatella conica*, *Marchantia nepalensis*, *Pellia calycina*, the last three going as far as the Kugti village, the last inhabited place on this side of the pass. A species of Porella was also met with a little lower down.

It will be seen therefore that there is nothing peculiar in the distribution as compared with the distribution in other parts of the Ravi valley. The forms were more numerous at higher levels up to a certain limit than at lower.

Trans-Himalayan region.

This part has been travelled by many people who collected plants during their travels but in most cases the collections were restricted to flowering plants. Very recently Stewart (5) visited this country and he has given a list of Cryptogams and Phanerogams. He does not, however, mention any Liverworts in the list.

The writer did not come across any Liverworts in Rupshu, i.e., from the Baralacha to the Tagblang la. In Ladak proper two species were met with:—*Marchantia polymorpha* and *Plagiochasma articulatum*. The first is pretty common in moist situations in many places which are comparatively low and was very abundant at Leh on the sides of drains, forming big patches. It was also fairly common at Kargil. The second was seen only at Leh and it was found forming a small patch just outside the town. The writer did not see any other Liverwort between the Baralacha on the one side and the Zoji la on the other. One would have expected more Liverworts at least just near the Zoji la owing to greater moisture but the cold probably prevents their growth.

Plagiochasma articulatum resembled the ordinary Himalayan form in all respects except that the appendages of the scales are a little broader and the line of the junction of the two successive shoots is not so well-marked. The specimens of *Marchantia polymorpha* are rather curious. The thallus is thin and broad as in the variety described as *aquatica* but the inner pores is quite different form what is described by Evans (1) or Stephani (4) and resembles the one given

by Muller in the new edition of Rabenhorst's Kryptogamen-flora (3). It has four projections of the surrounding cells passing into the central space while the greater part of this space is quite empty. It differs also from the var. *aquatica* in that the central dark band on the dorsal surface has pores on it whereas according to Evans they are absent in this region.

It is curious to note that Stephani (4) describes a *Porella* (*P. ovalis*) from Nubra from the collections of Hooker and Thomson. A Liverwort answering to the description of this species as given by Stephani has been found by the writer in abundance in the Chenab valley but I would not have expected a foliose form in Ladak. Even thallose forms which are distinctly xerophilous are rare as I have already said.

Kashmir Valley.

The valley of Kashmir gave a surprise. From his previous visits the writer had an impression that Kashmir was not very rich in liverworts but now it can be definitely stated that the number of species and individuals is far less in Kashmir in comparison to the eastern part of the Western Himalayas. The following species were collected :— An undescribed epiphytic species of *Porella* in the Sind valley below Sonamarg; a slightly different form of this species was collected at Verinag; *Marchantia nepalensis*, *Fegatella conica* and *Pellia calycina* were all met with in the rooms round the spring at Verinag. *Fimbriaria reticulata* was found by the writer on a former occasion in the same part of the country. It will be seen therfore that the number is very small, and even if we add to this the species described from Kashmir by other writers the number would still be quite small. On account of the great abundance of water one would have expected a much larger number of liverworts both as regards individuals and species. It is clear therefore that the general principle stated by the writer that the number of liverworts falls in going from the east to the west horizontally holds good for Kashmir also.

Jammu State.

More forms were met with on the way from the Banihal pass to Jummuo. The following is the list :—

Banihal village :—*Riccia sanguinea*, *Reboulia hemispherica*, *Pellia calycina*, *Marchantia nepalensis* and a *Porella* were met with a little lower down.

Ramsu (a little below the village) :—*Plagiochasma appendiculatum*. Patni pass (the richest place) :—*Marchantia nepalensis*, *Reboulia hemispherica*, *Plagiochasma appendiculatum*, *Athalamia pinguis*, *Fim-*

briaria mussuriensis, *Pellia calycina*, *Fossombronia himalayensis*, a foliose form, and *Anthoceros himalayensis*. The *Fimbriaria* showed a peculiarity in that the plants possessed terminal carpocephala in addition to these formed on short ventral shoots.

These forms are more like those found in other parts of the outer Himalayas to the east but of course the number is still very small. Between Dharmtal and Udhampur :—*Plagiochasma appendiculatum P. articulatum*, *Grimaldia indica*, *Riccia himalayensis*.

The lists naturally are not exhaustive but they give a fairly accurate idea of the relative number of forms met with in the different parts.

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AN ECOLOGICAL STUDY OF DECCAN GRASSLAND

By W. Burns, D.Sc., and G. M. Chakradev, B.A.

Introduction.

Previous work on the improvement of grazing lands made it clear that an intense ecological study of these lands is desirable. The present paper is a short account of the first season of such a study.

We have been able to lease for five years a piece of the worst Deccan grazing land near Poona, (*See plate*). This plot measures seven acres. Its surface is very uneven. On two sides it is raised into small hills, through which the rock shows. A central part is traversed by a nullah and has a piece of deeper soil in it. The whole area has been subjected to grazing and trampling by cattle from time immemorial, and it is usually accidentally burned every hot weather. It was so burned just before we took it over, and hence we were provided with a partially denuded area.

On the hilly portions the soil has been washed to such an extent that the existing plants are growing in *murum*, the partially disintegrated trap rock which lies about in fragments large and small. The lower areas have much more soil. Analyses of the soil taken at three different points are given in Appendix A. The low content of humus in the poorer samples is worth notice.

The area is about 1,800 ft. above sea level. The annual rainfall averages 27 inches, falling between June and October, both months included. During the rest of the year the climate is moderate as Indian conditions go, except for the intensely drying hot wind that blows from the west in the three months preceding the monsoon.

Operations on the Area.

The main thing in our research was to keep off cattle, prevent burning, and stop grass-cutting for such time as would enable us to study the possibilities of the vegetation if left to itself. A strong barbed wire fence was therefore erected, and a line of *Agave sisalana* planted inside it. To minimise erosion due to rain, small ridges of six to twelve inches high were erected along the contours at about each three-foot rise, and these ridges were reinforced by the loose stones of the area. The existing nullahs were blocked at various places to prevent the water rushing through them and



carrying away soil. A preliminary survey was made for the sake of ascertaining the above-mentioned contours, and another, more accurate, was made latter on, for a map. Approximately one-third of the whole area, consisting of a strip in the middle 250 feet broad, running from end to end of the area, was ploughed and harrowed in April 1920, and in June seeded with the grasses mentioned in Appendix B. The idea of this sowing was to see whether by seeding we could hasten the production of good grass on the area, and the extirpation of the existing poor grasses. In addition, three strips of land at right angles to this seeded strip were sown with bajri (*Pennisetum typhoideum*). This seed was broadcasted on the strips, and no cultivation was given except that which had been already given for the other grass seeding. Bajri is the natural crop of such poor land in the Deccan, and seeds were put in as it was thought that the growth of the plant in successive years might give an indication of the improvement of the soil.

Methods of Investigation.

The vegetation was studied by—

(1) marking out and charting quadrats in typical spots.
(2) watching certain individual plants.
(3) studying the plant societies of the area.

The method of investigation by quadrats is now well known to all ecological workers. To make our meaning clear, we venture, however, to give a brief explanation of it.

A quadrat is a square plot. It may be of any size, but is usually one metre square. It is sub-divided into 100 decimetre squares. All plants in the quadrat are plotted on to paper squared to represent the lines marked on the soil. Clements' method of laying out a quadrat is by tapes. We have constructed a wire grid of a metre side with cross wires at the decimetres. This grid when laid on the ground marks out the quadrat at once. In tall vegetation this grid is apt to be unhandy, but in low vegetation it is easily handled.

Six quadrats were studied inside the area and two outside it for comparison. Each was located in a different consocies, to use Clements' term. The quadrats were permanently marked by driving in pegs at the corners. Certain typical plants were transferred to the Agricultural College and there planted for further study.

General Observations.

The rains broke on June 2. Appendix C gives an idea of the season's rainfall. There was, as will be seen, a good preliminary fall, a long break, another good fall, another break, and finally rain in time to save the vegetation. On June 15, there was general greenness, and

the appearance of *Scilla indica*, *Boerhaavia diffusa*, and *Evolvulus alsinoides* in flower. On July 7th, vegetation was in profuse growth. In addition *Kyllinga triceps* was in flower in the uncultivated part, and an enormous number of *Lochnera pusilla* in the cultivated strip. On July 21, *Cyanotis tuberosa* and *Commelina Forskalæi* were a marked feature of the area, and among the grasses: *Tripogon Roxburghianus* was in flower, marking with its brown colour the poorer spots. The larger and coarser grasses seemed to be about to flower, and *Andropogon monticola* had shown some inflorescences. *Striga densiflora* was visible on August 8, in flower. *Cyanotis fasciculata* flowered on August 19 particularly on the poor and rocky spots, and on the same date *Andropogon contortus*, the main spear-grass, began to flower all over the area. On August 21, *Striga lutea* and *Lagasca mollis* flowered, and later in the month *Leucas longifolius*, *Pulicaria Wightiana*, and *Andropogon pertusus*. In September *Tripogon Roxburghianus* was drying up, but *Heliotropium merifolium* and *Zornia diphylla* were in flower, along with *Alysicarpus* species, and *Indigofera* species. The *Evolvulus alsinoides* was not less prominent. Later appeared *Lepidagathis cristata*, *Apluda varia*, *Heylandia latebrosa*, *Panicum flavidum*. and *Andropogon triticeus*. *Tripogon Roxburghianus* was, on October 21, putting out new growth on account of the late rains. On this date also *Thelepogon elegans* was in flower, and *Anthistiria ciliata* and *Andropogon pumilus* were also flowering.

The above very rough list will give some idea of the facies of the vegetation at various times of the season. It will be noted that there are three kinds of plants. (1) shortlived vernal plants like Scilla; (2) late season plants like *Heylandia*; and (3) plants of the whole season like *Evolvulus*.

The Quadrats.

Quadrat 1 is on poor soil. Before the rains broke it had on it mats of an unknown grass in a dry condition. These never sprouted, but appear to be of *Andropogon contortus*. On the break of the rains a sparse vegetation broke out all over the quadrat. One plant of *Evolvulus alsinoides* took possession of a central position, and gradually spread its arms over the greater part of the square. The early grass of the quadrat was *Tripogon Roxburghianus*, and the late one *Andropogogon contortus*. A few plants of *Oropetium Thomæum*, a minute and exceedingly xerophytic grass, were also found. This quadrat was twice nearly dried out.

Quadrat 2 is situated on a spot much lower down with more water and soil. The difference in vegetation is striking. The early grasses were *Cynodon dactylon* and *Setaria glauca*. Later appeared,

Panicum ramosum, *Eleusine ægyptiaca*, *Tripogon Jacquemontii* *Anthistiria ciliata*. and *Panicum colonum*. There was no *Andropogon contortus*. The grass was up to three feet high.

Quadrat 3 is the most xerophytic of all. It is situated partly on sheer rock. The early rains brought out *Kyllinga triceps* and a plant of *Chlorophytum tuberosum*. *Oropetium Thomaeum* was present, and later a mass of *Cyanotis fasciculata*. *Gracilea Royleana* was also seen.

Quadrat 4 is situated at the base of the slope down from the last quadrat. *Tripogon Roxburghianus* is absent. The early vegetation consisted of *Panicum ramosum*, *P. javanicum*, and *Gracilea Royleana*. Later appeared *Eleusine aegyptiaca*. *Paspalum sanguinale*, *Aristida redacta*, *A. funiculata*, *Setaria glauca*. *Manisuris granularis*, *Sporobolus diandra*, *Eragrostis tenella*, *Andropogon pumilus*, *Indigofera cordifolia*, *Zornia diphylla*, *Commelina Forskalaei*, *Celosia argentia*, *Phascolus trilobus*. *Spermacoce stricta*, *Striga species* and *Pulicaria Wightiana*. Here we have a very varied assortment of plants.

Quadrat 5 is situated on a low-lying but well-drained part representing a *Boerhaavia* society. This plant was in flower throughout the season. The other species found were *Gracilea Royleana*, *Zornia diphylla*, *Eleusine ægyptiaca*, *Tridax procumbens* and *Striga densiflora*. In September *Andropogon contortus* was dominant in this quadrat.

Quadrat No. 6 was taken in a distinctly hygrophytic spot in a low-lying place where water stood for a time after heavy rain. It contained large tufts of grass which did not flower till late when they proved to be *Andropogon caricosus*, var. *mollicomus* (dominant), *A. annulatus* (dominant) and *A. contortus*. Previous to this, in July, there had been in flower *Polygala chinensis*, and *Alysicarpus tetragonolobus*. *Acacia arabica* seedlings were visible on the plot in the early part of the rains, but with two exceptions disappeared later, being probably drowned out.

Outside Quadrats.

Quadrat X 1. This plot was chosen outside the fenced area on ground as similar as possible to that where Quadrat 1 is sited. From the start it showed a very even vegetation, consisting of grass seedlings and *Evolvulus alsinoides*. The grass turned out to be *Andropogon contortus* and remained stunted. *Indigofera linifolia* later occupied a fair part of the quadrat. Cattle wandered over this quadrat. We were never present when actual feeding took place on it, and there were no tooth marks visible on the grass blades. It was, however, almost certainly grazed at some period.

Quadrat X 2 was chosen on a piece of land approximating in nature and conditions to that of Quadrat 2. It was in a low-lying area

and the grasses on it flowered late. In it were found *Polygala chinensis*, *Alysicarpus rugosus*, *Justicia quinquefolia* and *Alysicarpus tetragonolobus*. The grasses visible in October were *Tripogon Jacquemonti*, *Iscilema laxum*, *Andropogon pumilus*, *A. caricosus*, *Apluda varia*, *Lophopogon tridentatus*, and the sedge *Fimbrystylis diphylla*. These outside quadrats will be kept up as controls to see what happens outside as compared with the protected area. It is also proposed to denude a quadrat each year at the side of the already mapped quadrats in order to see the nature of the succession more clearly.

From the first year's work on the vegetation by means of the quadrats just described we learn, of course, little except the composition of the vegetation. The most interesting thing is the great variation to be found within a quite small area, if the soil conditions alter. The lower part of the plot is filled with excellent grass in good quantity. There is therefore considerable hope that if the actual soil conditions can be altered by judicious treatment, there is nothing in the climate to prevent the development of really good grass land out of the present useless surfaces, in years of normal rainfall.

Study of Individual Plants.

This study has not yielded anything very startling, except the fact that there are definite races of *Evolvulus alsinoides*, *Andropogon contortus* and *A. monticola*. These are being further investigated.

Study of Societies.

This study is also not far advanced. One or two societies have been delimited and their spread or otherwise will be watched. The boundary between the hill flora and that of the lowlying area has been carefully marked.

The Cultivated Middle Strip.

In the early part of the season plant-growth on this strip was sparse as compared with that on the untouched strips. This was due to the thorough ploughing and harrowing given, and the apparently feeble germination of the sown seeds. The plant *Lochnera pusilla* however appeared in profusion, probably from seeds buried in the soil. By Sept. 1, the *Lochnera* had disappeared. Of the artificially sown grasses only one, *Andropogon purpureo-sericeus*, came up thickly. It has done best on the lower levels, and made little progress on the hill. It has again proved its value as a pioneer grass in artificial seedings, as it had previously done in the Ganeshkhind experiments.

Andropogon contortus appeared on the cultivated area but in patches only. *Andropogon monticola* was prominent in the cultivated area, some of this from the sown, and some from the original seeds probably. The same remark applies to *A. annulatus* and *A. caricosus*. Other grasses of the strip were *Paspalum sanguinale*, *Manisuris granularis*, *Iseilema anthophoroides*, *Aristida redacta*, *A. adscensionis* *A. funiculata*, *Panicum ramosum*, *P. javanicum*, *Eleusine aegyptiaca*, and *Thelepogon elegans*.

The bajri appeared very late, and then only as a few scattered dwarf plants.

Summary and Conclusions.

We have followed for one rainy season the behaviour of a small piece of bad land in the Deccan. We are struck with the variation of vegetation in so small an area, the soil conditions determining the species. In rocky and eroded soil found on high levels certain poor grasses dominate, in the deeper and moister soils of the lower levels, the vegetations consists of good fodder grasses.

Even in the higher and rocky parts however, the good fodder grasses *Iseilema laxum* and *Andropogon monticola* have firmly established themselves. Both are perennials. It is not too much to hope that they will gradually dominate the higher levels, thereby fixing the soil, and gradually producing the conditions suitable for the more tender *Andropogon annulatus* and *Andropogon caricosus*.

There is nothing in the climate, except when the rains fail to prevent these excellent fodder grasses establishing themselves if the land conditions are right. The question appears to resolve itself into one of permanent land improvement.

The question arises: What stage of the succession are we at? It can hardly be the climax, in an area so trampled, burned and grazed as this is. Is it the very first stage of the *sere*, to use Clements' term? It is difficult to say, but in certain parts of the area we cannot be far off the initial stage, marked in this case by the small short-lived and xerophytic grasses *Oropetium Thomaeum* and *Tripogon Roxburghanus*. Future years will enable us to pronounce on this point with more decision.

What may we expect as the climax, woodland or grassland? The climate is typically neither a woodland nor a grassland climate. Rainfall is confined to five months of the year. In the hot months all the aerial parts of grasses die. Trees have to be of the most xerophytic character to stand these dry months also. From observations of the neighbourhood, it would appear likely that the climax is *Acacia arabica* forest. *Acacia arabica* is checked in its young stages

by the browsing of goats. In later stages, of course, its pods make excellent goat fodder and its wood is invaluable for fuel and for country implements. An ideal condition of this land would be grassland containing the better fodder grasses with a scattered growth of *Acacia arabica*, not sufficient to shade more than a tenth of the land. Is there any reason why this condition of things should not come about?

There is one reason only. That is, the present difficulty, we do not say impossibility, of keeping cattle and men off any part of such areas in order to allow them even for a year to recuperate. Fencing, is necessary, and the goodwill and co-operation of the people concerned. There is, however, one village in the Nasik district where without fencing, the people annually set apart certain portions of their grazing lands for a rest. If this can be done in one village why should it not be done in all, with or without fencing?

At present it seems as if wire fencing were out of the question. There seems to us no reason why prickly pear (*Opuntia clatior*) already found in quantity near every village should not be used as a live fence. It may be objected that to plant this is spreading a pest. We may point out that it is easily kept in control, and that it also gives a useful ration in famine years.

The question is not insoluble, and it has *got* to be solved.

Cattle are the foundation of India's Agricultural wealth. Without cattle, tillage, manure, milk, and money crops are impossible. The question of the improvement of grasslands is therefore fundamental, and we hope that our feeble contribution to its solution may be of some little use.

APPENDIX A.

Analyses of three soil samples from the Kalas Plot.

Physical Analyses	Soil sample	Percentages	
	1	2	3
Finest silt and fine silt ...	14·86	19·24	14·66
Medium silt	3·19	3·89	1·55
Coarse silt	10·15	11·34	6·90
Fine sand	23·90	14·70	15·97
Coarse sand, including stones ...	47·90	50·83	60.92
	100.00	100·00	100·00
Humus in same samples ...	0·44	1·50	0·50

APPENDIX B.

Grasses and legumes sown on the cultivated strip.

Name	Amount in lbs.
Andropogon purpureo-sericeus	70
A. monticola	20
A. caricosus	10
A. pertusus	10
Thelepogon elegans	25
Anthistiria ciliata	20
Ischaemum sulcatum	20
Apluda varia	20
Tephrosia purpurea	2
Psoralea corylifolia	1
Indigofera glandulosa	5

Rainfall at Kalas.

June—October, 1920.

APPENDIX C.

Date.	June	July	Aug.	Sept.	Oct.	Date.	June	July	Aug.	Sept.	Oct.
1	*Nil*	*Nil*	0·49	*Nil*	0 04	17	*Nil*	0·05	*Nil*	*Nil*	*Nil*
2	0·15	,,	0·39	,,	,,	18	,,	0 09	,,	,,	0 08
3	0·26	1·90	0·09	,,	*Nil*	19	,,	*Nil*	,,	0·35	1·32
4	*Nil*	*Nil*	0·10	*Nil*	,,	20	,,	0·10	,,	1·72	0·08
5	,,	0·09	*Nil*	0·12	,,	21	0·09	0·04	,,	1·82	*Nil*
6	2·29	0·12	0·34	*Nil*	0·01	22	*Nil*	0·08	,,	0·66	0·06
7	*Nil*	0·07	*Nil*	,,	0·04	23	,,	*Nil*	,,	0·26	*Nil*
8	,,	1·38	,,	,,	,,	24	,,	0·15	,,	0·43	,,
9	0·11	0·42	,,	,,	*Nil*	25	,,	*Nil*	,,	0·02	,,
10	*Nil*	0·18	,,	,,	,,	26	,,	0·10	,,	0·47	,,
11	0·20	0·09	,,	0·01	,,	27	0·05	0·12	,,	0·68	,,
12	0·22	0·10	0·07	0·33	,,	28	*Nil*	0·05	,,	0·09	,,
13	0·71	0·09	,,	*Nil*	,,	29	,,	*Nil*	0·11	0·27	,,
14	*Nil*	0·07	0·02	,,	,,	30	,,	0·03	0·06	*Nil*	,,
15	*Nil*	0·06	0·02	,,	,,	31	...	0·33	0·17	...	,,
16	0·22	0·1	*Nil*	,,	0·16						

CURRENT LITERATURE.

Physiology.

Gardner, W. W. and Allard, H. A. Effect of the Relative Length of Day and Night and Other Factors on Growth and Reproduction in Plants. *Jour. Ag. Res. 18. 11. 1920.*

The length of the day is one of the most important factors in determining the periodicity of plants as regards vegetative or reproductive development. It far out-weighs in importance such factors as temperature, moisture supply or actual amount of light.

The authors carried on extensive experiments with plants grown in receptacles which could be moved at will from daylight into dark chambers. Shortening the day affected different plants differently. Some had their flowering period brought on more quickly and some had their vegetative period indefinitely prolonged and became gigantic in size. Some species when exposed to relative day and night lengths favourable to both growth and reproduction assumed an " ever-blooming " type of development, the two processes of growth and reproduction proceeding together for an indefinite period.

The seasonal range in the length of the day is an important factor in the natural distribution of plants. Its influence probably accounts for the frequent failure of plants to thrive when removed through a wide range of latitude. Note for example the frequently unsatisfactory behavior of English-grown vegetable seeds in India.

This work suggests possibilites to the horticulturist who would plant at the season which will enable his crop to secure the highest benefit of seasonal day and night length. It also suggests as has since been demonstrated in a practical way, that the greenhouse grower may control his product, hastening or prolonging its maturity, by the simple control of this factor.

L. A. K.

Chilcott, E. C. and Cole, John S. Sub-soiling, Deep Tilling and Soil Dynamiting in the Great Plains. *Jour. Ag. Res. 14. 11. 1918.*

The belief is general that deep tillage or the use of explosives enables the roots of a crop to penetrate more deely into the soil and helps the crop to overcome drought. Careful experiments were carried out with these processes on various parts of the Great Plains region of the United States, and the yield determined in the case of various crops grown in that region. In some cases the special treatment showed a benefit, but this benefit was by no means general and in almost no case was it sufficient to pay the increased cost of the treatment. In seasons which owing to drought are below the average in productivity, breaking the sub-soil appears to reduce the yield. Experiments performed in various parts of America, humid and arid, and in semi-arid Southern Russia give conclusions which in general agree with those of the authors.

L. A. K.

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THE PHYSIOLOGICAL ANATOMY OF THE PLANTS OF THE INDIAN DESERT

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(*Continued from p. 73.*)

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SCROPHULARIACEAE.

Anticharis linearis *Hochst.*—Fig. 245 (*Axis only*). Epidermal cells tabular. Cuticle smooth. Guard-cells elevated. Trichomes straight and smooth-walled. Cells of the outermost layer of cortex showing collenchymatous differentiation. Pericycle forming a loose ring of groups of bast fibres. Wood-ring broad. Vessels small and arranged in incomplete long rows. Interfascicular wood prosenchyma extensive and formed of cells with thick walls and with small lumen. Medullary rays uniseriate and numerous. Pith of thin-walled cells.

Schweinfurthia sphaerocarpa *Braun.*—Figs. 246, 247. Epidermal cells of the leaf and axis tabular. Large conical unicellular knobbed hair-like structures intercalated amongst ordinary epidermal cells. Cuticle striated. Trichomes curved and with walls covered with cuticular knobs. Mesophyll bifacial. Guard-cells elevated. Stomata on both the surfaces. Cells of the outermost layer of cortex showing collenchymatous differentiation. Pericycle in the form of isolated bast fibres. Wood-ring narrow. Vessels large and arranged in complete rows. Medullary rays absent. Interfascicular wood prosenchyma little developed and composed of cells with thin walls and large lumen. Pith of thin-walled cells.

Structure of the Leaf.—The epidermis in *S. sphaerocarpa* (fig. 246) consists on both sides of tabular cells with the outer walls greatly

thickened and convexly arched outwards. There are large unicellular conical hair-like structures, with walls covered with cuticular knobs, intercalated amongst ordinary epidermal cells (fig. 246). The lateral walls are thin and undulated. The inner walls are thin. The cuticle is striated. The stomata are equally numerous on both the surfaces and are surrounded by ordinary epidermal cells. The guard-cells are elevated and the front cavity is on a level with the surface.

The mesophyll is bifacial. Internal secretory organs and oxalate of lime are not found. The veins are embedded and are not enclosed in bundle-sheaths. The hairy covering on the axis consists of thin-walled uniseriate trichomes. Trichomes in *S. sphaerocarpa* are covered with cuticular knobs. Large conical epidermal cells with walls covered with cuticular knobs (figs. 246, 247) may be of the nature of unicellular hairs in *S. sphaerocarpa*. The trichomes in *A. linearis* are smooth-walled and straight. Glandular hairs are not found.

Structure of the Axis.—Epidermis consists of tabular cells with outer walls greatly thickened and convexly arched outwards. Cuticle is striated. There are large concical unicellular hair-like structures with walls covered with cuticular knobs intercalated amongst ordinary epidermal cells in S. *sphaerocarpa* (fig. 247). Lateral walls are thin and straight. The stomata are like those on the leaf. The cortical parenchyma is composed of horizontally elongated cells. The cells of the outermost layer of the cortex show collenchymatous differentiation at angles in contact with the epidermal cells.

The pericycle consists of a few isolated bast fibres and of a loose ring of groups of bast fibres in *S. sphaerocarpa* (fig. 247) and *A. linearis* (fig. 245) respectively. The wood forms a composite hollow cylinder. The vessels in *S. sphaerocarpa* (fig. 247) are arranged in complete rows; interfascicular wood prosenchyma is little developed and is composed of cells with thin walls and with large lumen. The vessels in *A. linearis* are small and are arranged in long incomplete rows; the interfascicular wood prosenchyma is extensive and is composed of cells with thick walls and with small lumen. The medullary rays are uniseriate and numerous in *A. linearis*; they are absent in *S. sphaerocarpa*. The pith is composed of thin-walled cells.

ACANTHACEAE.

Blepharis sindica *T. Anders.*—Figs. 248, 249, 250. Outer walls of epidermal cells greatly thickened. Guard-cells elevated. Front cavity on a level with the surface. Mesophyll formed of palisade tissue on the upper side and of subepidermal aqueous tissue and palisade tissue on the lower. Veins provided with bundle-sheaths.

Clothing hairs unicellular and conical. Glandular hairs formed of a stalk-cell and of a spherical head divided by horizontal and vertical walls. Crystal sand in the clothing hairs of the leaf and in epidermal cells of the axis. Collenchyma forming a continuous ring. Aqueous tissue occurring below collenchyma. Pericycle in the form of isolated bast fibres. Vessels uniformly distributed in the wood-ring. Interfasciculer wood prosenchyma fairly extensive. Wood parenchyma fairly extensive. Medullary rays few and uniseriate. Pith of thin-walled cells.

Ruellia patula *Jacq.*—Fig. 251. Guard-cells elevated. Front cavity on a level with the surface. Mesophyll of palisade tissue on the upper side and of arm-palisade tissue on the lower. Veins not provided with bundle-sheaths. Clothing hairs uniseriate and more or less jointed. Glandular hairs with an uniseriate stalk and with a disc-shaped head divided by horizontal and vertical walls. Assimilatory tissue in the axis parenchymatous. Structures resembling internal glands found in cortex. Pericycle of a few isolated bast fibres. Wood composed of large bundles at the angles and connected by strands of interfascicular wood prosenchyma. Wood parenchyma in groups on the inner side of xylem bundles. Medullary rays uniseriate. Pith of thick-walled cells.

Barleria hochstetteri *Nees.*—Figs. 252, 253, 254, 255, 256, 257. Guard-cells in the plane of surrounding cells. Mesophyll isobilateral. Veins without bundle-sheaths. Structures resembling internal glands present. Clothing hairs on the leaf short and unicellular, and those on the axis in the form of armed trichomes. Glandular hairs with an uniseriate stalk and with a disc-shaped head divided by a vertical wall. Collenchyma strengthening the ribs. Assimilatory tissue in the axis parenchymatous. Sclerenchymatous pericycle not developed. Vessels uniformly distributed in the wood-ring. Wood narrowed at two opposite points. Medullary rays uniseriate. Interfascicular wood prosenchyma little developed. Pith of thin-walled cells and retained. Pith cells with acicular or rod-like crystals. A thick-walled vessel present in pith.

Justicia simplex *Don.*—Fig. 258, 259. Guard-cells elevated or in the plane of surrounding cells. Mesophyll isobilateral. Structures resembling internal glands found in the mesophyll. Veins without sheaths. Clothing hairs short and uniseriate. Glandular hairs with a stalk-cell and with a spherical head divided by horizontal and vertical walls. Assimilatory tissue in the axis formed of palisade cells. Collenchyma developed at the angles of the quadrangular axis. Sclerenchymatous pericycle not developed. Wood composed of xylem bundles at the angles connected by strands of interfascicular wood pro-

senchyma. Wood parenchyma developed on the inner side of the xylem bundles. Medullary rays absent. Pith of thin-walled cells.

Structure of the Leaf.—The epidermis consists of polygonal cells in *R. patula*, *B. hochstetteri* and *J. simplex* or of tabular cells as in *B. sindica*. The outer walls are thickened, thickening being considerable in *B. sindica*. The outer walls are convexly arched outwards and the lateral walls thin and undulated in *J. simplex*. The cells are uniformly thickened on all sides in *R. patula* and *B. hochstetteri*; the lateral walls are undulated. The lateral and inner walls are also thickened in *B. sindica* and the latter are undulated.

Numerous large rounded cells are intercalated amongst ordinary epidermal cells; and each contains a spherical cystolith (fig. 258). The stomata are accompanied by subsidiary cells. The guard-cells are usually elevated and the front cavity is on a level with the surface in all members except *B. hochstetteri* in which the guard-cells are in the plane of surrounding cells and the front cavity is a little depressed. The stomata are more numerous on the lower surface except in *B. sindica* where they are more numerous on the upper surface. This may be accounted for by the occurrence of subepidermal aqueous tissue on the lower side where there should be as few stomata as possible to economise the supply of water contained in the aqueous tissue. The mesophyll is isobilateral except in *R. patula* in which it consists of palisade tissue on the adaxial side and of arm-palisade tissue on the abaxial side. In *B. sindica* there is palisade tissue on the adaxial side and subepidermal aqueous tissue and palisade tissue on the abaxial side.

In *B. hochstetteri* and *J. simplex* there are peculiar structures on both sides of the mesophyll. They are at some places circular in section and are composed of irregular cells faintly green in colour; at other places they have the form of secretory cavities with bounding cells projecting into them (fig. 258). These structures probably represent the internal secretory organs. Oxalate of lime does not occur in the form of crystal sand in the cell-cavity of clothing hairs on the leaf and in the epidermal cells of the axis of *B. sindica*. The veins are embedded and are not enclosed in bundle-sheaths.

The hairy covering on the leaf and axis consists of clothing and glandular hairs. The clothing hairs in *R. patula* (fig. 251) and *J. simplex* (fig. 258) are simple uniseriate trichomes with thickened and muriculate walls; the constituent cells in the former are dilated at the lower end and give a jointed appearance to the trichomes. In *B. hochstetteri* there are unicellular elliptical hair-like structures with walls thickened and muriculate on the leaf; on the axis, besides the long simple uniseriate trichomes (fig. 255), there are other special

forms which consist of a stalk-cell and of a terminal cell which is unicellular and two-armed and sometimes with a small scale on its upper side (figs. 256, 257). The walls of these different forms of hairs in *B. hochstetteri* are muriculate. The clothing hairs in *B. sindica* (fig. 249) are unicellular and conical and have walls thickened and muriculate.

External glands occur on the leaf and axis of all members. In *B. sindica*, *R. patula* and *J. simplex* they are placed in epidermal depressions and consist of a stalk-cell and of a spherical head divided by horizontal and vertical walls (fig. 258). Glandular hairs on the axis of *R. patula* and on the leaf and axis of *B. hochstetteri*, consist of a long uniseriate stalk and of a disc-shaped head divided either by a vertical walls (figs. 253, 255) or both by horizontal and vertical walls.

Structure of the Axis.—The epidermal cells are tabular in *B. sindica* and *J. simplex*; they are polygonal in *B. hochstetteri* and *R. patula*. The outer walls are thickened. There are numerous large cells, circular in T. S., intercalated amongst ordinary epidermal cells, each containing a rounded cystolith (fig. 251). The stomata on the axis are like those on the leaf. The stomata situated on the sides of furrows in *B. hochstetteri*, however, are elevated a good deal above the epidermis.

The primary cortex is characterised by the occurrence of collenchyma which forms larger groups at the angles and smaller ones between them. The collenchyma in *B. sindica* forms a continuous ring. The assimilatory tissue in *R. patula* and *B. hochstetteri* is formed of chlorenchyma, while in *J. simplex* it consists of large thin-walled cells which occasionally act as water-reservoirs.

Sclerenchymatous pericycle is not developed except in *B. sindica* and *R. patula*, in which it consists of isolated bast fibres. The wood is composite in all members; it is of uniform breadth except in *R. patula*, in which it is much narrowed at two opposite points. The wood in *B. hochstetteri* and *J. simplex*, is composed of large xylem bundles at the angles connected by strands of interfascicular wood prosenchyma with a few rows of vessels embedded in them. The vessels in *B. sindica* and *R. patula* are uniformly distributed in the interfascicular wood prosenchyma. The narrowed portions of the wood-ring represent the plane at right angles to the direction of the wind. The medullary rays are uniseriate. They are numerous in *B. hochstetteri*. The wood parenchyma is little developed in *B. sindica* and *B. hochstetteri* while in *R. patula* and *J. simplex* it occurs in groups on the inner side of the angular xyem bundles.

The pith is composed of thin-walled cells except in *R. patula* in which it consists of thick-walled cells. Oxalate of lime is found in

the form of bundles of acicular or rod-like crystals in the pith cells of *B. hochsteiteri*. Anamolous structures are represented by isolated thick-walled vessels in the pith of *B. hochstetteri*.

General Review.—Epidermal cells have the outer walls thickened. There are large cells, containing rounded cystoliths, intercalated amongst ordinary epidermal cells. The stomata are accompanied by subsidiary cells. Mesophyll is either isobilateral or is composed of palisade tissue on the upper and of arm-palisade tissue on the lower side. Structures resembling internal glands are found in the mesophyll of some members. Oxalate of lime is found only in the pith cells of *B. hochstetteri*, in the form of bundles of acicular or rod-like crystals. Besides simple unicellular hairs or uniseriate trichomes which are of general occurrence, there are special forms of trichomes such as armed trichomes on the axis of *B hochstetteri*. External glands are found in all members. The assimilatory tissue in the axis is composed of chlorenchyma or of palisade cells. The collenchyma either forms groups or is found in the form of a more or less continuous ring, below the epidermis. An aqueous tissue is found in the leaf and axis of *B. sindica*. Sclerenchymatous pericycle occurs only in *R. patula*, in the form of isolated bast fibres. The wood forms a composite ring. The interfascicular wood prosenchyma is fairly extensive in members in which the vessels are not uniformly distributed. The pith consists of thin-walled or thick-walled cells. Anamolous structures are represented by thick-walled vessels in the pith of *B. hochstetteri*.

VERBENACEAE.

Bouchea marrubifolia *Schauer.*—Figs. 260, 261, 262. Pl. XXVI. Epidermal cells tabular with outer walls very greatly thickened. Guard-cells accompanied by two subsidiary cells. External glands composed of a uniseriate stalk and of an elliposidal bicellular head. T. S. of the axis quadrangular. Pericycle formed of groups of the stone-cells. Cork absent.

Cleredendron Phlomidis *L.f.*—Figs. 263, 264. Epidermal cells tabular with outer and inner wall equally a little thickened. Guard-cells accompanied by 4-5 ordinary epidermal cells. External glands composed of a stalk-cell and of a broad elliptical head divided by many vertical walls. Pericycle forming a loose ring of stone-cells. Cork developed below collenchyma. T. S. of the axis circular.

Structure of the Leaf.—The epidermal cells are tabular with the outer and inner walls thickened, the thickening of the outer walls being considerable in *B. marrubifolia* (fig. 260). The lateral walls

are thin and straight. The stomata occur on both the surfaces and are accompanied by subsidiary cells in *B marrubifolia* and by 4 or 5 ordinary epidermal cells in *C. Phlomidis*. The guard-cells are a little elevated and the front cavity is placed in depressions formed by thickened outer epidermal cells.

The mesophyll is composed of palisade tissue on the upper side and of arm-palisade tissue on the lower. Internal secretory organs and oxalate of lime are found neither in the leaf nor in the axis. The veins are embedded and are not provided with bundle-sheaths.

The hairy covering on the leaf and axis consists of clothing and glandular hairs. Clothing hairs occur in the form of unicellular or bluntly pointed uniseriate trichomes with muriculate walls. The clothing hairs are more numerous on the lower surface. The glandular hairs are placed in epidermal depressions. They are composed in *C. Phlomidis* of a stalk-cell and of a broadly disc-shaped head divided by many vertical walls (fig. 264). In *B. marrubifoli* (fig. 262), they consist of a short uniseriate stalk and of a disc-shaped head divided by an oblique wall.

Structure of the Axis.—The epidermal cells are tabular, with outer walls thickened and muriculate in *B. marrubifolia*, and thin and convexly arched outwards in *C. Phlomidis*. The lateral walls are thin and straight. The primary cortex is composed on its outer side of collenchyma and on its inner side of cortical parenchyma. Cork is developed below the collenchyma in *C. Phlomidis*. Cortical parenchyma is of uniform breadth in *C. Phlomidis* and is more extensive in the plane exposed to the wind in *B. marrubifolia*.

The pericycle consists of a more or less composite ring of stone-cells in *C. Phlomidis* and of groups of stone-cells in *B. marrubifolia*. The stone-cell tissue is more extensive in the plane exposed to the wind in *B. marrubifolia*. The wood forms a composite hollow cylinder. The vessels are large and are uniformly distributed in incomplete rows in the extensive interfascicular wood prosenchyma. Medullary rays are 1-2 seriate and are numerous.

The pith consists of thin-walled cells.

LABIATAE.

Salvia aegyptiaca *L.*—Figs. 265, 266, 267. Upper epidermal cells larger. Epidermal cells tabular with outer walls very greatly thickened. Stomata on both the surfaces and accompanied by subsidiary cells. Mesophyll formed of palisade tissue on the upper and of arm-palisade tissue on the lower. Internal glands and oxalate of

lime absent. Veins without bundle-sheaths. Clothing hairs uniseriate trichomes. Glandular hairs spherical. Epidermal cells of the axis with outer and inner walls thickened. T. S. of the axis quadrangular. Collenchyma in the angles. Pericycle of stone-cells groups. Assimilatory tissue in the axis of palisade cells. Endodermis differentiated and with radial walls suberised. Wood composite. Interfascicular wood prosenchyma extensive and composed of cells with thick walls and with small lumen. Medullary rays uniseriate. Pith of thin-walled cells.

Structure of the Leaf.—The epidermis consists of tabular cells with the outer walls very greatly thickened. The cells on the upper side are larger than those on the lower. The lateral walls are thin and straight.

The stomata occur on both the surfaces and are accompanied by subsidiary cells. The guard-cells are elevated and the front cavity is placed in a depression formed by outer thickened epidermal walls. The mesophyll is composed of palisade tissue on the upper side and of arm-palisade tissue on the lower. Internal glands and oxalate of lime do not occur in the leaf or axis. The veins are not enclosed in bundle-sheaths. The leaves are many-ribbed. The veins of the ribs are vertically transcurrent above and below by colourless parenchyma.

The hairy covering on the leaf and axis consists of clothing and glandular hairs. Clothing hairs are in the form of uniseriate trichomes with verrucose walls (fig. 266). They are more numerous on the lower surface. The trichomes on the axis are much longer; but are otherwise like those on the leaf (fig. 267). External glands occur in two forms on the leaf and axis. They either consist of a short uniseriate stalk and of a spherical unicellular head, or are formed of a stalk-cell and of a bladder-like head the cuticle of which is raised like a bladder, owing to the accumulation of secretion.

Structure of the Axis.—The T. S of the axis is quadrangular in outline with shallow grooves between the angles. The epidermis consists of small tabular cells with the outer and inner walls thickened. The outer walls are convexly arched outwards. The internal walls are thin and straight. The cuticle is thick. The cortex (fig. 267) is characterised by subepidermal strands of collenchyma situated in the angles. The assimilatory tissue consists of strands of palisade cells between the collenchyma at the angles. The endodermis is distinct and consists of thin-walled cells with radial walls suberised.

The pericycle is composed of groups of stone-cells at the angles (fig. 267). The wood is composed of large xylem bundles at the angles and of small ones between them. The interfascicular wood

prosenchyma is extensive and is composed of thick-walled cells with small lumen. The medullary rays are uniseriate and numerous. Wood parenchyma is little developed.

The pith consists of thin-walled cells.

NYCTAGINACEAE.

Boerhaavia diffusa *L.*—Figs. 268, 269. Upper epidermis of cubical cells. Lower epidermis of tabular cells. Epidermal cells of the leaf and axis with tanniniferous contents. Palisade tissue on the upper side and round the veins. Aqueous tissue below lower epidermis. Veins with thick-walled green sheaths. Glandular hairs with a uniseriate stalk and with an ellipsoidal head. Epidermal cells of the axis polygonal. Pericycle formed of isolated bast fibres. Endodermis of thick-walled tabular cells.

Boerhaavia verticillata *Poir.*—Epidermis of both sides of tabular cells. Mesophyll bifacial. Glandular hairs absent. Veins without bundle-sheaths. Pericycle forming a loose ring of bast fibres. Endodermis of thin-walled tabular cells.

Boerhaavia elegans *Chois.*—Fig. 270. Specific characters almost the same as those of *B. diffusa*. From the point of view of anatomical characters it should belong to the same species.

Structure of the Leaf.—The epidermis on the upper side of *B. diffusa* and *B. elegans* consists more or less of cubical cells with the outer and inner walls a little thickened. The latter are convexly arched outwards. The lower epidermis in *B. diffusa* and *B. elegans* and the epidermis on both sides in *B. verticillata* consists of tabular cells with the outer walls thickened and convexly arched outwards. The lateral walls are thin and straight in all members. The granulated appearance of the outer walls is due to the deposits of crystaline granules of calcium oxalate; and the granulated walls are covered by a thick cuticle. The occurrence of deposits of calcium oxalate in the epidermal walls of these succulent plants protects them from desiccation as well as from being easily devoured by animals on account of the acrid taste.

Stomata occur on both the surfaces and are surrounded by ordinary epidermal cells. The guard-cells are situated in the plane of surrounding cells and the front cavity is placed in a depression formed by the upper portions of surrounding cells.

The mesophyll in *B. diffusa* and *B. elegans* is composed of palisade tissue on the upper side and about the veins and of a tissue of thin-walled colourless polygonal cells with probably a water-storing function on the lower side. In *B. verticillata* palisade tissue

occurs on the upper side; and there is an extensive tissue, occupying two-thirds of the portion of mesophyll, of thin-walled polygonal cells faintly green in colour and partly functioning as an aqueous tissue.

Internal secretory organs are represented by epidermal cells, with tanniniferous contents, of the leaf and axis of *B. diffusa* and *B. elegans*.

Oxalate of lime, besides being deposited in the form of granules in outer epidermal walls, occurs in the form of bundles of raphides and of crystal sand in mesophyll of leaves and in the primary cortex of the axis of all members. Granular deposits in the outer epidermal walls are abundant and give to the surface of the leaf and axis a whitish appearance, which besides protecting these succulent plants from being easily devoured by animals on account of the acrid taste, reflect light and arrest transpiration.

The veins are embedded and are enclosed in thick-walled green bundle-sheaths in *B. diffusa* and *B. elegans*. Bundle-sheaths are not found in *B. verticillata*.

The hairy covering consists of glandular hairs and occurs on the axis and both the surfaces of the leaf of *B. diffusa* and *B. elegans*. The glandular hairs (fig. 268) are composed of a uniseriate long stalk and of an elongated and ellipsoidal head. The cells of the stalk become narrower towards the apex. External glands are not found in *B. verticillata*.

Structure of the Axis.—The epidermal cells in *B. diffusa* are polygonal, while those in *B. verticillata* are tabular. The outer walls are thickened, convexly arched outwards and granulated with deposits of calcium oxalate. The primary cortex (fig. 269) is composed of collenchyma on its outer side and of chlorenchyma on the inner side. The endodermis is distinct and is composed of tabular cells which are thick-walled in *B. diffusa* and *B. elegans*.

The pericycle consists either of isolated bast fibres as in *B. diffusa* and *B. elegans* or of a loose ring of bast fibres in *B. verticillata*. The wood is characterised by the occurrence of two rings of xylem bundles. The primary bundles are small and are embedded in a thin ring of interfascicular wood prosenchyma which is composed of cells with thick walls and with small lumen. The secondary bundles are irregularly arranged in the pith and are separated by broad strips of thin-walled parenchymatous cells, resembling medullary rays. Soft bast is found in groups on the outer side of xylem bundles.

The pith tissue between the primary and secondary vascular bundles consists of cells with thickened and lignified walls and filled with granular contents, and that between and enclosed by the secondary vascular bundles is formed of very thin-walled cells.

AMARANTACEAE.

Aerua tomentosa *Forsk.*—Figs. 271, 272, 273, 274. Mesophyll bifacial. Veins with bundle-sheaths. Mid-rib prominent above and below. Clustered crystals in the leaf and axis. A dense covering of candelabra hairs on the leaf and axis. Collenchyma in the angles of the axis. Assimilatory tissue in the axis chlorenchymatous. Pericycle of groups of stone-cells. Pith of thick-walled cells.

Aerua pseudo-tomentosa *Blatt. & Hall.*—Figs. 275, 277, 280, 281. Mesophyll bifacial. Clustered crystals in the leaf and axis. Veins with bundle-sheaths. Mid-rib furrowed above and prominent below. A dense covering of candelabra hairs on the leaf and axis. Assimilatory tissue in the axis formed of palisade cells. Collenchyma in the angles. Pericycle of groups of stone-cells. Pith of thick-walled cells.

Achyranthes aspera *L.*—Figs. 282, 283, 284. Mesophyll bifacial. Clustered crystals in the leaf and axis. Veins without bundle-sheaths. Clothing hairs in the form of uniseriate trichomes with walls knobbed. Glandular hairs with a uniseriate long stalk and with an ellipsoidal head. Collenchyma in the angles. Assimilatory tissue in the axis chlorenchymatous. Pericycle of groups of stone-cells and isobilateral. Two vascular bundles in pith. Pith of thin-walled cells.

Pupalia lappacea *Moq.*—Figs. 276, 278, 279. Mesophyll bifacial. Oxalate of lime in the form of clustered crystals in the leaf and that of crystal sand in the axis. Veins without bundle-sheaths. Hairs uniseriate, curved and smooth-walled. Collenchyma in angles. Assimilatory tissue in the axis chlorenchymatous. Pericycle of groups of stone-cells and isobilateral. Pith of thin-walled cells.

Structure of the Leaf.—The epidermis consists of tabular cells with the outer and inner walls thickened and convexly arched outwards and inwards respectively. The lateral walls are thin and straight. The stomata are more numerous on the lower surface and are surrounded by ordinary epidermal cells. The guard-cells of the stomata on the upper surface are in the plane of surrounding cells and the front cavity is placed in a depression formed by outer thickened epidermal walls (fig. 275). The guard-cells of the stomata on the lower surface are a little elevated and the front cavity is on a level with the surface. The stomata on the axis are placed in depressions formed by outer thickened epidermal walls. The stomata are replaced by lenticels in the rhizomatous axes of *A. tomentosa*.

The mesophyll is composed of palisade tissue on the upper and of spongy tissue on the lower. Oxalate of lime occurs in the form of

large clustered crystals in the neighbourhood of veins of all members and in the cortex and pith of both species of *Aerua* and in *A. aspera*. In the rhizomatous axis of *A. tomentosa* numerous clustered crystals are present in the neighbourhood of water-storing tracheids, in many of the medullary ray cells and in the pith. In the axis of *P. lappacea* oxalate of lime is found in the form of crystal sand composed of triangular granules in the cortex and pith.

The veins are embedded except those of the mid-rib which are vertically transcurrent above and below by collenchyma. They are enclosed in bundle-sheaths of thick-walled green cubical cells in both the species of *Aerua*. The mid-rib is furrowed above and prominent below in *A. pseudo-tomentosa*, while in *A. tomentosa* it is prominent above and below.

The hairy covering (fig. 277) in the leaf and axis of both the species of *Aerua* consists of a dense covering of candelabra hairs which are more numerous on the lower surface. The underground rhizomatous axis of *A. tomentosa* is quite glabrous. Clothing hairs in *A. aspera* occur in the form of uniseriate trichomes composed of a few basal cells and of a long terminal cell curved as on a hinge. Walls are characterised by warts by means of which the hairs dove-tail with one another and form a dense covering (fig. 282). Besides clothing hairs, there are external glands composed of a uniseriate stalk and of an ellipsoidal head (fig. 283). Uniseriate trichomes in *P. lappacea* (fig. 279) are smooth-walled and consist of a basal portion of a few short cells and of a terminal portion which is curved and is composed of longer and jointed cells. The clothing hairs are filled with air and become white; they thus reflect light and glare and arrest transpiration.

Structure of the Axis.—The epidermis consists of small tabular cells with outer and inner walls thickened and convexly arched outwards and inwards respectively. The primary cortex is characterised by collenchyma at the angles and by an assimilatory tissue which is composed of palisade cells in *A. pseudo-tomentosa* and of chlorenchyma in other members. In the rhizomatous axis of *A. tomentosa* the assimilatory tissue is not developed. The assimilatory tissue in *P. lappacea*, forms a continuous ring, while in other members it occurs between collenchyma groups at the angles. There is a layer of green cells resembling the cells of the bundle-sheath, close below the assimilatory tissue of both the species of *Aerua*.

There is extensive development of cork in the rhizomatous axis of *A. tomentosa*. It extends between epidermis and pericycle and also between the latter and the groups of soft bast. It is partly of epidermal and partly of pericyclic origin.

The pericycle in both the species of *Aerua* consists of long thin groups of stone-cells. In the rhizomatous axis of *A. tomentosa* it forms a composite ring of stone-cells except at certain spots where stone-cells are not developed and where the space is occupied by the conjunctive tissue of medullary rays, which is very extensive where the gaps are large. Sometimes lenticels are found above these gaps; it may therefore be supposed that this conjunctive tissue forms a system of communication between the lenticels and the vascular tissue.

In *P. lappacea* the stone-cell groups of the pericycle are triangular. The bases of these groups on two opposite sides of the axis are lengthened out, so that adjacent groups unite and form composite strands, while on the other two sides the stone-cell groups are isolated, the pericycle thus presenting an isobilateral symmetry. In *A. aspera* a similar isobilateral arrangement is presented, but in a different way. The stone-cell groups on two opposite sides of the axis are longer and thinner than those on the other two. The isobilateral symmetry of pericycle may have been developed by the direction of the prevailing wind, the more composite structure being developed in the plane more affected by the wind.

The wood forms a composite ring. The interfascicular wood prosenchyma is much more extensive and is composed of cells with much more thickened walls and with much smaller lumen, in both the species of *Aerua* than in the case of *A. aspera* and *P. lappacea*. In *P. lappacea* the arrangement of xylem bundles is isobilateral, larger bundles being developed below the composite stone-cells strands and smaller ones below isolated stone-cell groups. This suggests that functional activity is greater on these sides which are more affected by the wind. In *A. aspera* there occur two vascular bundles in the pith with soft bast on their outer side and placed in the plane in which stone-cell groups form composite strands.

Soft bast forms groups on the outer side of xylem bundles in both the species of *Aerua*, while in *A. aspera* and *P. lappacea* it forms a continuous ring.

Pith consists of thick-walled cells in species of *Aerua*; in *A. aspera* and *P. lappacea* it is formed of large thin-walled cells.

The rhizomatous axis of *A. tomentosa* presents many anamolous structures. Wood forms a composite ring and is composed of a few xylem bundles with very large vessels. Medullary rays are unusually very broad; the broadest ones broaden outwards in the form of wedges and come into contact with the cork tissue. In addition to the outer wood-ring there is a central wood cylinder developed in the pith tissue. It is composed of four diagonally placed xylem bundles, two being

very large and with vessels large and many and the other two small with vessels small and few. Soft bast forms groups on the outer side of xylem bundles.

The central wood cylinder occupies nearly the whole of the pith. It is, I should say, secondarily developed when the axis took to a rhizomatous habit of growth ; it affords mechanical support against longitudinal pressure. In a rhizomatous axis the mechanical tissue, when necessary as a protection against longitudinal pressure cannot develop in any other form than in the form of a central cylinder. This is analogous to what is seen in the case of roots. Abundance of very large vessels is necessary on account of greater abundance of moisture in the soil than in the dry air outside. This affords an example of the great plasticity of plant structures which can admirably adapt themselves to changes in their surroundings.

Another anamolous structure is presented in the form of groups of water-storing tracheids in the middle of the cork-tissue, with clustered crystals in their neighbourhood. The occurrence of water-storing tracheids in the cork tissue can be accounted for by the abundance of lenticels.

The fact that the conjunctive tissue of medullary rays comes into direct contact with the cork tissue at certain spots where the medullary rays are very broad may be accounted for as means of bringing the lenticel tissue into direct contact with the water conducting tissue and thus increasing transpiration, as there may be abundance of water in the rhizomatous axis with numerous large vessels and with numerous water-storing tracheids.

The occurrence of vascular bundles in the pith of *A. aspera* forms an anamolous structure. They may be necessary for supplying the extensive thin-walled pith tissue with water and also for strengthening the same against the winds of the desert, as they are developed in a plane which corresponds with the direction of the prevailing wind.

General Review.—Epidermis consists of tabular cells with outer and inner walls thickened and convexly arched outwards and inwards respectively. Stomata are accompanied by ordinary epidermal cells. Hairy covering consists of candelabra hairs or of uniseriate trichomes, with walls smooth or muriculate. Collenchyma is developed at the angles. The pericycle consists of groups of stone-cells. Wood is composite. Medullary rays are absent except in the rhizomatous axis of *A. tomentosa*. The pith consists of thick-walled or of thin-walled cells. Some of the members present many anamolous structures which prove the remarkable plasticity of their tissues.

CHENOPODIACEAE.

Haloxylon recurvum *Bunge.*—Figs. 285, 286. Leaves semiterate. Epidermal cells with outer walls papillose. Stomata depressed. Aqueous tissue subepidermal and central. Palisade tissue continuous on the upper surface and broken by aqueous cells on the lower. A bundle-sheath like layer below palisade tissue and bringing into contact the assimilatory and vascular system. Veins peripheral and central and surrounded by small-celled parenchyma. Oxalate of lime in the form clustered crystals in the subepidermal and central aqueous tissue. T. S. of the axis circular. Assimilatory tissue in the axis of palisade cells. Pericycle of thin groups of stone-cells. Peripheral bundles traversing the central aqueous tissue and the central bundles embedded in interfascicular wood prosenchyma. Pith of thick-walled cells.

Haloxylon salicornicum *Bunge.*—Fig. 288. Epidermis of thin-walled tabular cells. Stomata depressed. Aqueous tissue subepidermal and central. Palisade cells forming a continuous ring. Clustered crystals in the form of a layer in subepidermal aqueous cells and also scattered in the central aqueous tissue of the leaf and axis. Bundle-sheath-like layer below palisade tissue and bringing into contact assimilatory and vascular tissues. Pericycle of stone-cell groups and isobilateral. Peripheral vascular bundles traversing the central aqueous tissue and the central vascular bundles embedded in interfascicular wood prosenchyma. Pith of thin-walled cells.

(*To be continued.*)

Plate XXV.

244. *Solanum incanum.*
T. S. of the axis.
Oc. 6 Com.; Ob. 8 mm. Ap.

245. *Anticharis linearis.*
T. S. of the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.

246-247. *Schweinfurthia sphaero carpa.*
246. T. S. of the leaf showing epidermis and hairs.
Oc. 4 Com.; Ob. 3 mm. Ap.
247. T. S. of the axis.
Oc. 6 Com.; Ob. 8 mm. Ap.

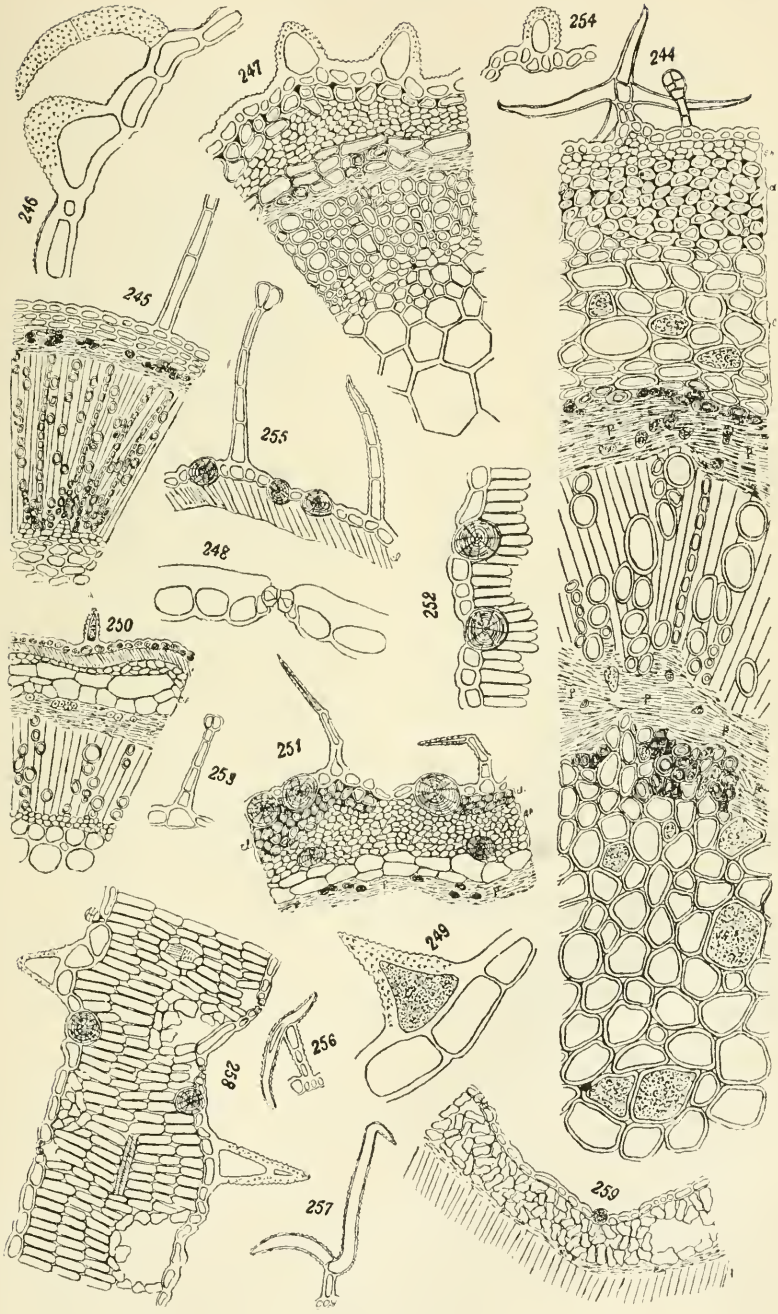
248-250. *Blepharis sindica.*
248. T. S. of the leaf showing epidermis and a stoma.
Oc. 6 Com.; Ob. 3 mm. Ap.
249. Hair on the leaf.
Oc. 6 Com.; Ob. 3 mm. Ap,
250. T. S. of the axis.
Oc. 6 Com.; Ob. 8 mm. Ap.

251. *Ruellia patula.*
T. S. of the axis.
Oc. 6 Com.; Ob. 8 mm. Ap.

252-257. *Barleria hochstetteri.*
252. T. S. of the leaf showing cystolith-like structures in epidermal cells.
Oc. 6 Com.; Ob 8 mm. Ap.
253. Glandular hair on the leaf.
Oc. 6 Com.; Ob. 8 mm. Ap.
254. T. S. of the leaf showing a hair.
Oc. 6 Com.; Ob. 8 mm. Ap.
255. T. S. of the axis showing hairs and cystolith-like structures in epidermal cells.
Oc. 6 Com.; Ob. 8 mm. Ap.
256, 257 } Hair on the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.

258-259. *Justicia simplex.*
258. T. S. of the leaf.
Oc. 6 Com.; Ob. 8 mm. Ap.
259. T. S. of the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.

N.B.—To get the original dimensions multiply by 1·7.

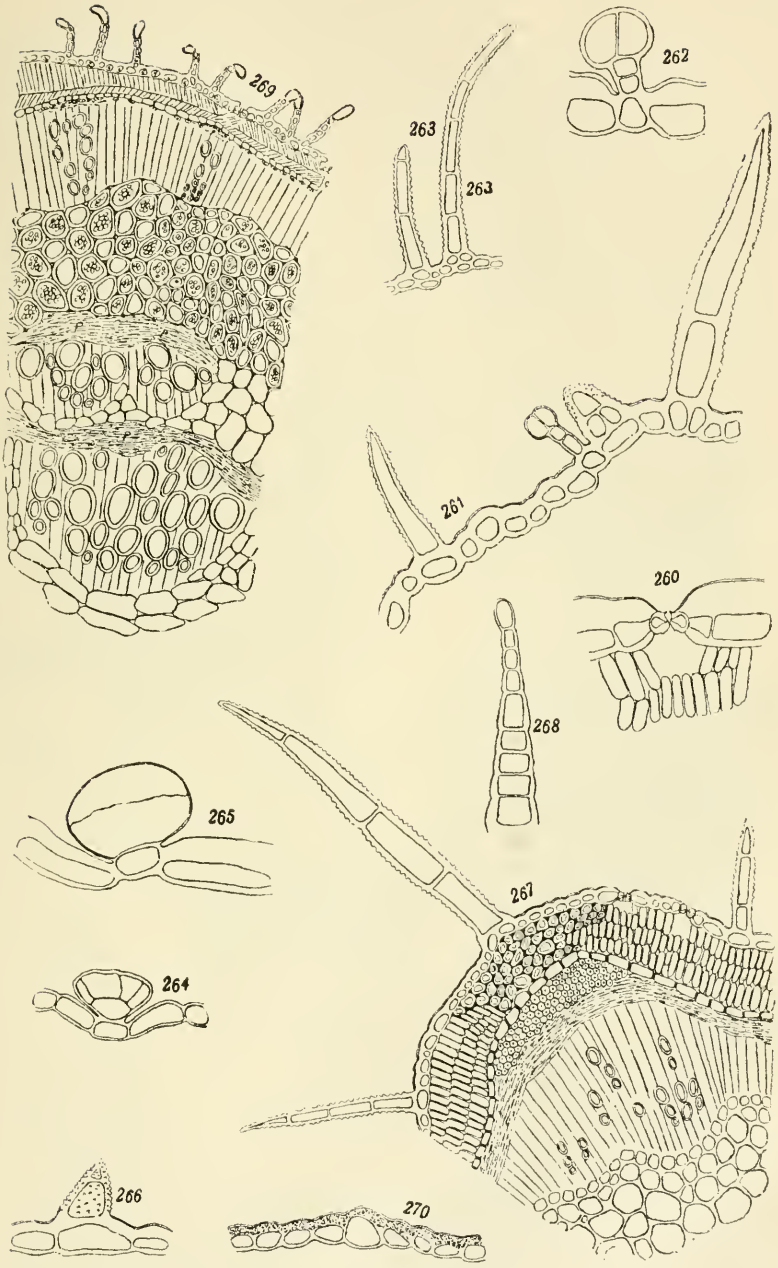


T. S. Sabnis del. PLATE XXV.

Plate XXVI.

260-262. *Bouchea marrubifolia.*
260. T. S. of the leaf showing a stoma.
Oc. 4 Com.; Ob. 3 mm. Ap.
261. T. S. of the axis showing epidermis and hairs.
Oc. 4 Com.; Ob. 3 mm. Ap.
262. Glandular hair on the axis.
Oc. 6 Com.; Ob. 3 mm. Ap.
263-264. *Clerodendron Phlomidis.*
263. Hair on the axis.
Oc. 8 Com.; Ob. 3 mm. Ap.
264. Glandular hair on the leaf.
Oc. 6 Com.; Ob. 3 mm. Ap.
265-267. *Salvia aegyptiaca.*
265. Glandular hair on the leaf.
Oc. 6 Com.: Ob. 3 mm. Ap.
266. Hair on the leaf.
Oc. 6 Com.; Ob. 8 mm. Ap.
267. T. S. of the axis.
Oc. 6 Com.; Ob. 8 mm. Ap.
268-269. *Boerhaavia diffusa.*
268. Glandular hair on the leaf.
Oc. 6 Com.: Ob. 8 mm. Ap.
269. T. S. of the axis.
Oc. 6 Com.; Ob. 8 mm. Ap.
270. *Boerhaavia elegans.*
T. S. of the axis showing epidermis.
Oc. 6 Com.; Ob. 8 mm. Ap.

N.B.—To get the original dimensions multiply by 1·7.

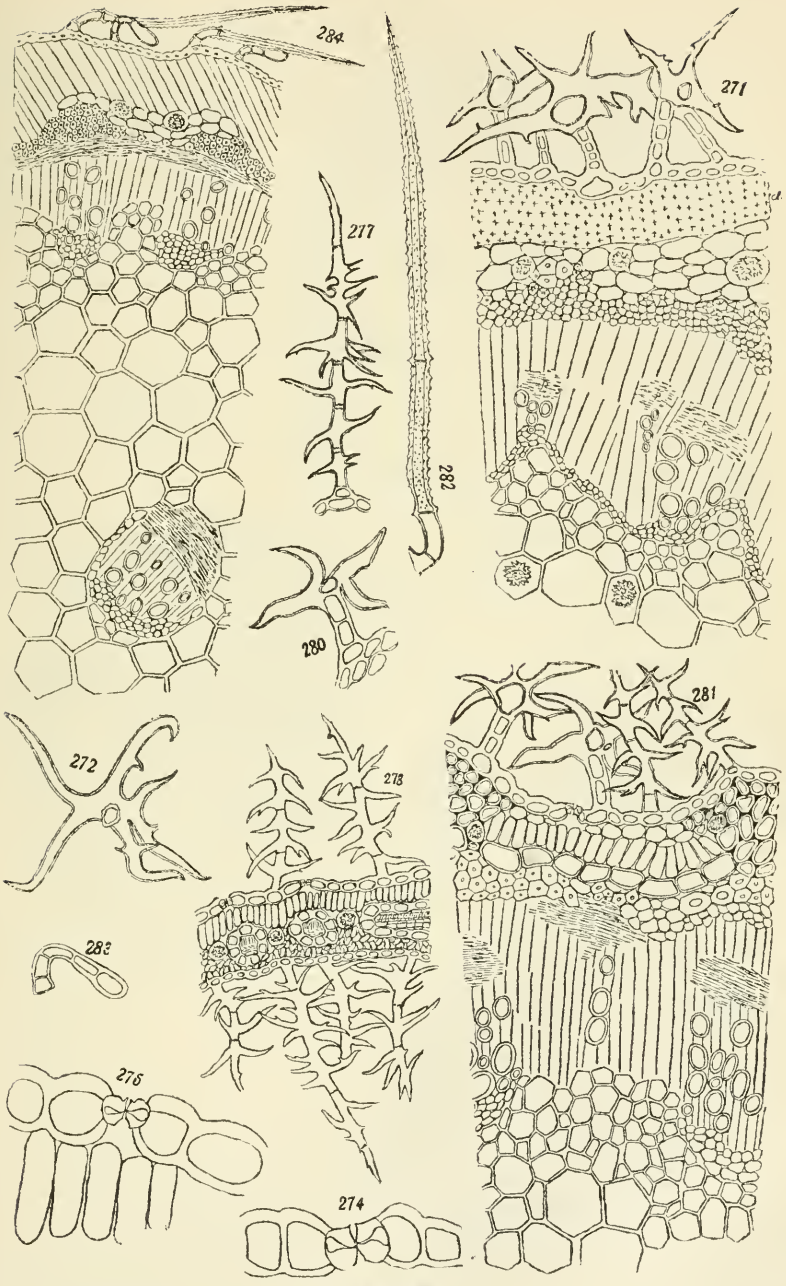


T. S. Sabnis del. PLATE XXVI.

Plate XXVII.

271-274. *Aerua tomentosa.*
271. T. S. of the axis.
Oc. 3 ; Ob. C.
272. Hair on the axis.
Oc. 3 ; Ob. C.
273. T. S. of the leaf.
Oc. 1 ; Ob. 8 mm. Ap.
274. Stoma on the leaf.
Oc. 3 ; Ob. 3 mm. Ap.
275-281. *Aerua pseudo-tomentosa.*
275. Stoma on the leaf.
Oc. 3 ; Ob. 3 mm. Ap.
277. Hair on the leaf.
Oc. 1 ; Ob. 8 mm. Ap.
280. Young hair on the axis.
Oc. 3 ; Ob. C.
281. T. S. of the axis.
Oc. 3 ; Ob. C.
282-284. *Achyranthes aspera.*
282. Hair on the axis.
Oc. 1 ; Ob. 3 mm. Ap.
283. Glandular hair on the axis.
Oc. 1 ; Ob. 3 mm. Ap.
284. T. S. of the axis.
Oc. 2 ; Ob. C.

N·B.—To get the original dimensions multiply by 1·7.

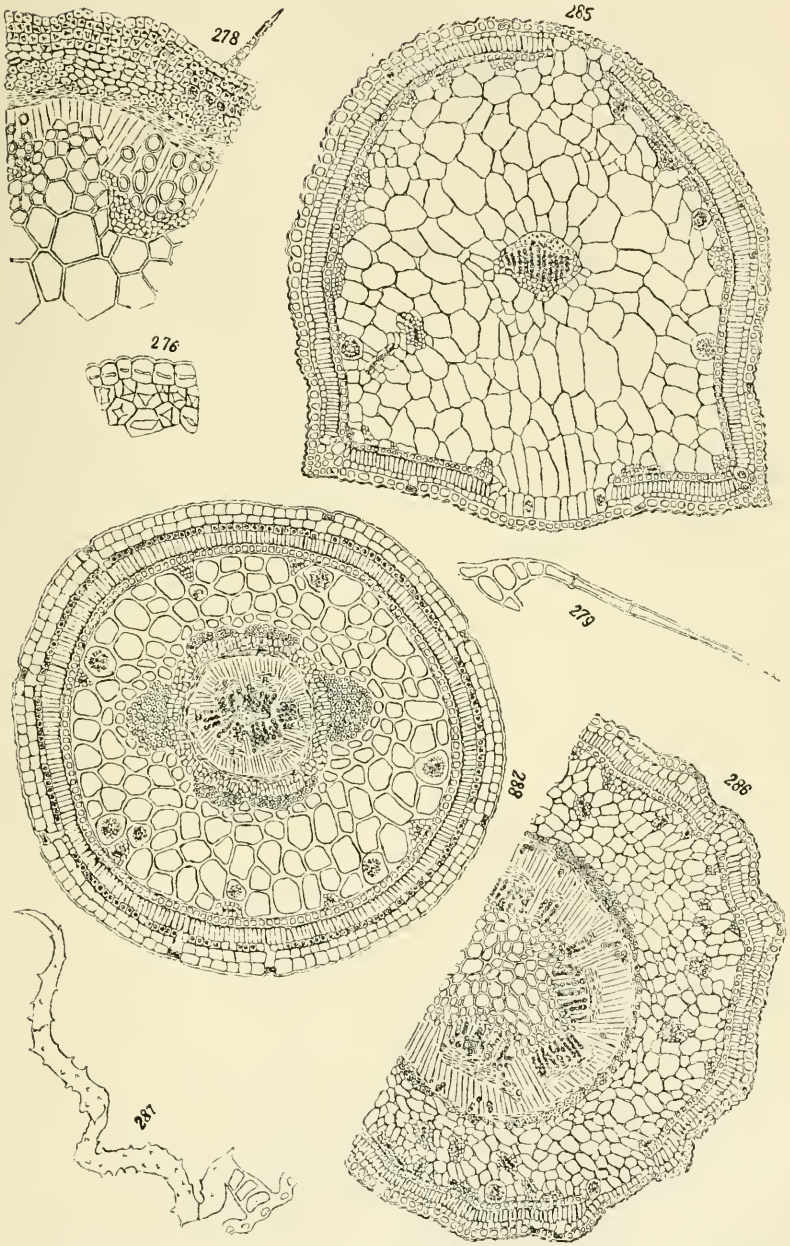


T. S. Sabnis del. PLATE XXVII.

Plate XXVIII

276-279. *Pupalia lappacea.*
276. T S. of the axis showing epidermis and collenchyma.
Oc. 4 Com. ; Ob. 3 mm. Ap.
278. T. S. of the axis.
Oc. 2 ; Ob. C.
279. Hair on the axis.
Oc. 2 ; Ob. C.
285-286. *Haloxylon recurvum.*
285. T. S. of the leaf.
Oc. 2 Com. ; Ob. 8 mm. Ap.
286. T. S. of the axis.
Oc. 2 Com. ; Ob. 8 mm. Ap.
287. *Salsola foetida.*
Hair on the axis.
Oc. 4 Com.; Ob. 3 mm. Ap.
288. *Haloxylon salicornicum.*
T. S. of the axis.
Oc. 2 Com.; Ob. 8. mm. Ap.

N.B.—To get the original dimensions multiply by 1·7.



T. S. Sabnis del. PLATE XXVIII.

SOME OBSERVATIONS ON CYCAS REVOLUTA AND C. CIRCINALIS GROWING IN LAHORE.*

By Shiv Ram Kashyap,

Professor of Botany, Government College, Lahore.

The observations described in this paper on leaf-clusters and ovules were made on plants of *Cycas revoluta* and *C. circinalis* growing in the Government College Botanic Garden and the Lawrence Gardens, Lahore. Some plants were planted in flower pots and were kept constantly under observation. *Cycas revoluta* is very commonly cultivated in Lahore gardens but *C. circinalis* is not so common. The writer has not come across any male plant of *Cycas revoluta* in Lahore or in its neighbourhood, all the plants being female. It is propagated by means of buds which grow on the underground or aerial parts of the stem. These buds when detached and planted grow into new plants which are naturally female. A few years ago the writer obtained some seeds of this species from Japan and these have produced some plants, but the latter have not as yet produced any flowers. *Cycas circinalis* is represented by many female plants but so far as the writer is aware there is only a single male plant in this locality, growing in a tub in the Lawrence Gardens. The female plants bear buds in fairly large numbers by which the plant is propagated, but the male plant has never produced any bud and therefore it is impossible to increase the number. Only one male cone is produced each year. It is formed during the rains and ripens towards the end of the rainy season, in August. The longest one measured during the last few years was more than eighteen inches, and the thickest, this year 1920, was nearly twelve inches in circumference at the thickest part.

Leaf-clusters of Cycas revoluta.—One series of observations on Cycas revoluta was meant to find out the interval between the successive leaf-clusters. Coulter and Chamberlain, in the recent (1917) edition of "Morphology of Gymnosperms" state :—"In Cycas revoluta it is said that a crown is formed every other year, but information in regard to the duration of the crowns, as they occur in the field, is scanty and uncertain." The observations recorded in this paper throw light on both these questions. No information about these matters is given in Chamberlain's recent book "The living Cycads."

Seedlings grown from seeds showed what is well-known, that the leaves at first appear singly and later on the number is gradually increased to two, three and more.

* A paper read before the Indian Science Congress at Calcutta, February, 1921.

Ten plants were propagated by buds from the female plants growing in the garden, and were kept in pots under uniform conditions. Observations were commenced when the plants were five or six years old. All the plants except No. 1 were in pots of the same size.

The former was in a large pot, it was the largest and probably the oldest. The pots of three plants got broken once at different times and were changed at once. It is however unfortunately not recorded what were the numbers of these plants. As is well known all the leaves do not appear quite simultaneously, but they arise gradually in some spiral, though the whole cluster is one unit.

The foliage leaves are always followed by scale-leaves. The number of leaves in each cluster in these plants varied between 6 and 20, the largest number being found in No. 1. In the rest the variation was not so great. None of these plants has so far produced any sporophylls. The following table gives the times at which the clusters of foliage leaves appeared during the two years for which the plants were kept under observation. The formation of the cluster is indicated by an asterisk under the month in which it was unfolded.

1916

——	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	...	...	*	...	...	...	...	...	...	...	...	...
2	...	...	...	*	...	...	...	...	...	...	...	...
3	...	...	...	*	...	...	...	...	...	...	[1] *	...
4	...	...	...	*	...	...	*	...	...	...	...	...
5	...	...	...	*	...	...	*	...	*	...	...	...
6	...	...	...	...	*	...	*	...	...	*	...	...
7	...	...	...	...	...	*	...	...	...	...	...	...
8	...	...	...	...	...	*	...	...	...	...	...	[2] *
9	...	...	...	...	...	[3] *	...	...	*	...	...	...
10	...	...	...	...	...	*	...	...	*	...	...	...

[1] Took a long time, about a month to unfold, Ordinarily the clusters in all plants unfolded within ten days.

[2] Stopped unfolding after a few days and the leaves fully opened only in the beginning of April, 1917 (*Vide* entry there).

[3] Ouly two leaves appeared at this time. Three more appeared after middle of July when the former were almost fully expanded. No scales were formed after the first two. The five thus belonged to the same cluster, the last three being for some reason or other delayed in their appearance.

The peculiar behaviour of the second clusters of No. 3 and 8 is apparently due to cold. The distinction between two clusters is easily determined by the formation of the scale leaves at the end of each cluster. The formation of the first cluster of No. 9 was thus spread out over one whole month, with a break in the middle.

1917

—	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	...	...	...	...	...	*	...	...	...	...	..	...
2	...	...	...	...	*	...	...	*	...	...	...	...
3	...	...	...	...	...	*	...	*	...	...	...	...
4	...	...	...	...	*	...	...	*	...	...	...	...
5	...	...	...	...	*	*	...	*	...	..	...	...
6	...	...	...	...	*	...	..	*	...	...	...	...
7	...	...	...	*	...	...	...	*	...	...	...	...
8	...	...	...	[1] *	...	*	...	...	...	...	...	...
9	...	...	...	...	*	...	...	*	*	...	...	...
10	...	...	...	...	...	*	..	...	...	...	...	...

[1] Continuation of the last year's cluster.

In both years the position of the asterisk, under the first, second or third letter of the month indicates that the cluster unfolded in the beginning, middle or end of the month respectively.

It would be seen that the number of the clusters formed by the ten plants during the two years were as follows :—

	1916	1917		1916	1917
1	1	1	6	3	2
2	1	2	7	1	2
3	2	2	8	2	1
4	2	2	9	2	3
5	3	3	10	2	1

It is clear that the largest and probably the oldest plant formed only one cluster each year. The rest formed one, two or three, and all of these formed more than one in at least one of the two years. From these observations and others given further on in the paper made on much older trees which were growing on land in the garden, it will be seen that in young plants more than one cluster is usually produced each year, while older plants produce only one cluster every

year and still older ones produce clusters every other year or even at longer intervals. It may be mentioned also that it is difficult to give the exact age of the plants as the time during which the buds had remained attached to the parent plants is not known.

Another series of observations was undertaken on four large plants growing in the Botanic Garden. These are certainly more than twenty years old at the least. All of them produced cones in May 1919, and the following measurements were taken in October 1919. The girth is about the same throughout the whole length of the stem except at the very base where it is a little smaller.

	Height to top of cone.	Height to lowest green leaf.	Girth about middle of stem.	Circumference of cone.
1.	3 ft. 2 in.	2 ft.	3 ft. 5 in.	3 ft. 3 in.
2.	4 ft. 3 in.	2 ft. 10 in.	3 ft. 6 in.	3 ft. 3 in.
3	3 ft. 5 in.	2 ft. 3 in.	3 ft. 2 in.	3 ft. 1 in,
4.	3 ft. 1 in.	1 ft. 10 in.	3 ft. 5 in.	3 ft. 3 in.

The trees were kept under observation from October 1918 to November, 1920. The following was the sequence in which the foliage leaves and sporophylls were arranged with the time of appearance where known :—

.....		Oct. 1919	May, 1919.	Oct. 1919.	Ap.—May. 1920.		Nov. 1920
1. Fol.	Spor.	Fol.	Spor.	...	Fol.		...
2. Fol..	Spor.	Fol.	Spor.	...	Fol.	Spor.	Fol.
3. Spor.	Fol.	Fol.	Spor.	...	...		...
4. Spor.	Fol.	Fol.	Spor.	...	Fol.		...

The number of foliage leaves in each cluster was usually about sixty, and the number of sporophylls in each cluster varied between 120 and 170. It will be seen that there is no invariable alternation between the foliage leaves and the sporophylls though in many cases it is distinctly present. Again a cluster of foliage leaves appears usually after about eighteen months, though a cluster of sporophylls appears before the second foliage cluster in the meantime. We can say that usually one cluster appears every year whether of foliage leaves or sporophylls. Plant No. 2, however is very curious in this respect. It produced a cluster of foliage leaves in April and immediately after that a cluster of sporophylls about the end of May. Even now its activity was not quite exhausted and it produced another cluster of foliage leaves in November, 1920 when the other three trees showed nc sign of forming any leaves. This behaviour is quite unusual but the cause of this excessive activity is not known.

In No. 4 three clusters of green leaves were visible below the cone, but in the others only two such clusters were present. The leaves below them had all died and therefore been cut away. On the

basis that a leaf cluster appears every other year the age of a leaf cluster would thus be from four to six years.

Ovules of Cycas Revoluta.

As has been mentioned above there are no male plants of *Cycas revoluta* anywhere near Lahore. Naturally therefore one would not expect ripe seeds on the female plants. It is interesting to note however that ripe ovules, with fully formed endosperm and archrgonia but without embryos, do occur occasionally. Le Goc has studied the same phenomenon in *Cycas Rumphii* in Ceylon. (Ann. Roy. Bot. Gard. Peradeniya, 1917, 6). He also finds well-developed ovules in that species though he did not see any male plants in the locality. He thinks that the development of the ovules is due tc the influence of foreign pollen which he found in the pollen-chamber, obviously implying that the presence of the pollen grains is necessary not only for the formation of perfect seeds but also for the full development of the ovules. Without going into a discussion of this question it may be stated that in Lahore a very great majority of the ovules of *Cycas revoluta* shrivel after some time and only a few occasionally develop the endosperm and archegonia. It has not as yet been determined whether they receive any foreign pollen or not. There are a few male and female plants of *Zamia* growing near these plants of *Cycas revoluta* and a male plant of *Cycas circinalis* is growing in a tub at some distance. Although the female plants of *Zamia* do produce a few ripe ovules and seeds, the female plants of *Cycas circinalis* growing in the garden have not so far been seen to form ripe ovules or seeds. The connection of the development of the ovules of *Cycas revoluta* with foreign pollen, if any such connection exists, will be investigated at an early date.

The ordinary ovule of *Cycas revoluta* which has not fully developed is more or less spherical with the sides flattened or depressed and possesses a notch at the tip. The ripe ovules met with on the same plants are very much larger, do not show any flattening of the sides, and but are rounded and gradually taper towards the apex which is very distinctly acutely pointed. This last character is very curious especially because in the ripe seeds obtained from Japan the tip shows the usual notch, or at least there is no tapering at the upper end. (*Vide* fig. 1.)

Another interesting point in this species is the occurrence of intermediate forms between the sporophylls and the scales. The sporophylls, as is well-known, are pinnately divided organs in which the lower pinnae are replaced by ovules and thus correspond to the foliage leaves, but of course are smaller, brown and whoolly. The sporophylls

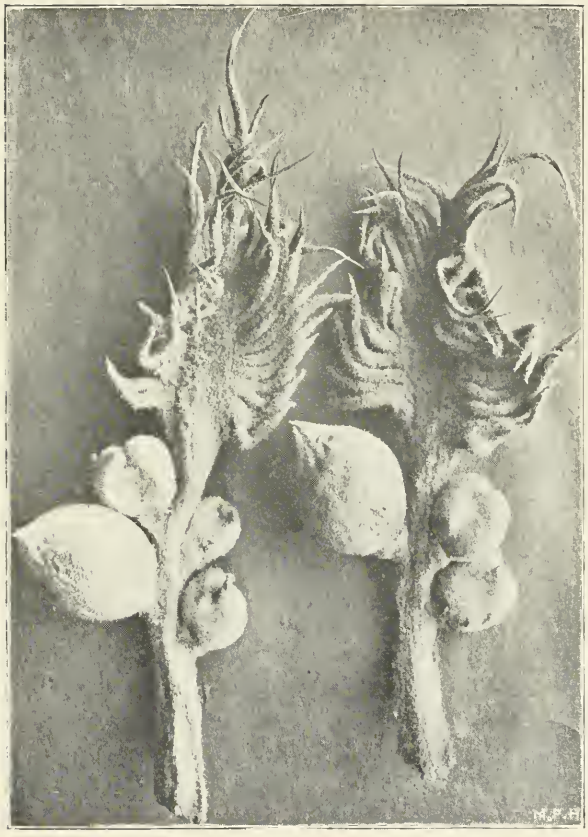


FIG. 1.

formed last in the cluster remain sterile, their pinnae remain small, the ovules are absent, and the pinnae are restricted to the upper part only. This reduction gradually leads to the sharply-pointed scales without any trace of the pinnae, but there is a complete series of intermediate forms between the two extremes. The sterile intermediate forms very much resemble the sporophylls of *Cycas circinalis* without the ovules. (*Vide* fig. 2.)



FIG. 2.

Cycas Circinalis.

The accompanying photograph shows a very curiously branched tree of *Cycas circinalis*. It is growing in the Lawrence gardens, Lahore. The tree is known to have been growing there for more than thirty years and on the basis of one leaf-cluster every other year is more than eighty years of age. The history is that the apex was cut off at the place were the first bifurcation is seen and a scar is present at the fork. But after that the tree has not been interfered with. The repeated dichotomies form a very interesting feature of the plant and remind one of the fossil Cycadophyta like *Wielandiella*.[1] Four distinct dichotomies can be traced from the base

[1] *Vide* Scott. Evolution of Plants, page 89.

to the apex along one side of the tree. Another curious feature of the tree is that at some places the female sporophylls do not arise on all sides of the growing point as is normally the case but are developed only on one side. This may possibly indicate a tendency to variation in the position of the female cone from terminal to lateral, but nothing definite can be said about this matter without further investigation.

Since writing the above the writer has seen two more specimens of apparently the same species growing in the Royal Botanic Garden at Calcutta which are also branched in the same way. It is probable that the dichotomy is not real but only due to the growth of some of the buds which are so common on the stem of this plant. It may also be mentioned that Brandis (Indian Trees) says that *Cycas Rumphii* is often branched.

Literature cited.

1. Brandis. Indian Trees.
2. Chamberlain. Living Cycads.
3. Coulter and Chamberlain. Gymnosperms, 1917.
4. Le Goc. Effect of Foreign Pollination on *Cycas Rumphii*. Ann. Roy. Bot. Gard. Peradeniya, 1917, 6.
5. Scott. The Evolution of Plants.

Description of Figures.

1. Sporophylls of *Cycas revoluta* with unripe and ripe ovules.
2. Transition from a sporophyll to a scale.
3. Cycas circinalis showing peculiar habit.



FIG. 3.

NEW BOMBAY SPECIES.

By L. J. Sedgwick.

Leucas angustissima *L. J. Sedgwick, Sp. nova. Herba* saxicola, erecta, ad 30 cm alta. *Radix* lignosa. *Caulis* lignosus, a basi ramosus. *Rami* secundi, virgati, angusti, quadrangulares et quadri-sulcati. *Folia* perangusta, linearia, ad 30 × 3 mm, marginibus revolutis. *Verticelli* omnes axillares, pauciflori. *Pedicilli* perbreves. *Calyx* 6 mm longus, sensim curvatus, bucciniformis, extus minutissime hispidus, intus glaber ; os obliquum, nudum, supra productum ; dens superior sublongus, ceteri perbreves. *Corolla* pro rata magna, conspicua ; tuba 5 mm longa ; labium superius 3 mm longum et latum, villo albo indutum ; labium inferius deflexum, patens, conspicuum, 9 mm longum, infra puberulum ; lobi 3 ; lobi laterales angusti, decurvati ; lobus medius 7 mm latus, emarginatus.

In patentibus saxis, prope Gairsoppa Falls in Canara in provincia Bombaiensi, ad alt. circa 1500 ped. angl. et pluv. circa 100 digit. angl., Sedg. et Bell 7234, Nov. 1919 ; et apud Siddhapur in eadem regione Sedg. et Bell 7255, eodem mense ; cotypi in Herb. Coll. Sanct. Xavieri, Bombay. Invenit quoque in Herb. Talbot, 3740 a Siddhapur.

A very distinct species, with the habit and conspicuous flowers of *L. longifolia* Benth., but a very different calyx, resembling a small form of the calyx of *L. linifolia* Spreng.

Christisonia flammea *L. J. Sedgwick, Sp. nova. Herba* humilis, in Strobilanthis radicibus parasitica. *Caules* aggregati, demum erecti, tantundem elongati ut flores e tellure emergant, 4 mm lati. Squamulae 5 × 4 mm, distantes, ovatae, obtusae. *Flores* in racemis congestis, corymbiformibus ; bracteae squamulis assimiles, sed majores : bracteolae 2. *Pedicilli* 0, vel ad 2 cm longi. *Calyx* rufo-brunneus, dense et conspicue puberulus ; tuba ad 2 cm longa, 1 cm lata, pentagona ; lobi 5, aequales, triangulares, 5 mm longi. *Corolla* aureo-lutea, ad 5 cm longa, bucciniformis ; tuba a medio inflata, extus dense puberula ; lobi 5, aequales, curtissimi, perobtusi, demum patentes. *Stamina* corollae dimidio aequantia, didynama ; filamenta alba, puberula ; antherae conniventes, crescentiformes ; loculus superior apice infra porum subulatus ; loculus inferior sterilis, commatiformis. *Stylus* stamina longe excedens, albus, glaber ; stigma bilobum ; lobi crassi, rotundati. *Ovarium* biloculare. *Capsula* globosa, 12 mm lata, styli basi persistente apiculata. (See Fig. p. 127.)

In Strobilanthis variarum specierum radicibus parasitica, apud Gairsoppa Falls in Canara, sed solum in fluminis australi, id est Mysorensi, ripa observata, ad alt. circa 1500 ped. angl. et pluv. 150—200 digit. angl. Collegerunt Bell, Sedgwick, Hallberg et McCann, Nov. 1919. In herbario Sedg. et Bell. Cotypi in herbario Coll. Sanct. Xavieri, Bombay.

Apparently exceedingly close to *C. aurantiaca* Wt. Ic. 1486, which was united with *C. bicolor* Gardner by Hooker in F. B. I. IV p. 322. The drawing in the Icones however shows a less elongate and less elegant type of flower. The calyx is broader and conceals more of the tube of the corolla. In the plant from Gairsoppa the calyx is much narrower, and the slender corolla tube is clearly exerted.

Phyllanthus Talboti *L. J. Sedgwick, Sp. nova. Frutex* erectus, ad 1 m altus, in rivorum fluminibus saxicola. *Caulis* saepius simplex, nigrescens, striatus. *Rami* crebri, ad 15 cm longi, exceptis tenellis glabri. *Folia* numerosissima, creberrima, disticha, patentia, sed in herbario secunda, a 3·5 × 1·5 mm ad 9 × 3·5 mm, oblonga, acuta, supra glabra, subtus glabra, glabrescentia, vel puberula. *Stipulae* a basi lata lineares, *Flores masculi* in omni axilla fasciculati; *pedicilli* ad 3 mm longi. *Calycis* lobi 4, imbricati, late ovati, obtusi, dorso saepius minute sericei, marginibus integris scariosisque. *Discus* 4-lobatus; lobi magni, rotundati. *Antherae* 4, in summae columnae margine transverse dispositae. *Flores feminei* in axillis solitarii; calycis lobi 6, imbricati, ovati, glabri, marginibus integris. *Discus* annularis. *Ovarium* stipitatum, 3-loculare, albis tubercellis subscabridum; styli 3, alte bifidi, reflexi. *Cocci* distincti, dorso rotundati, supra producti et stylos excedentes, scabridi, sed deinde glabri, et ab axi separate decidui. *Semina* glabra, lutea. (See Fig. p. 129.)

In fluminibus Canarae in Provincia Bombaiensi, apud Supa, Sedg. et Bell 4869, Nov. 1918, et apud Jog (Gaisoppa) Talbot 828, A.D. 1883, Sedg. et Bell 7073, Nov. 1919. Utriusqe loci alt. circa 1500 ped. angl.; pluv. circa 100-200 digit. angl.

This was passed over by Talbot as being *P. Lawii* Graham, the habitat being the same. But it differs from that species in habit, the plant being taller, and the branches much longer and less rigid. In the structure of the male flower it is, of course, quite different, *P. Lawii* having three erect acute anthers. It belongs to Hooker's Sec. *Riedia*.

Ceropegia fantastica *L. J. Sedgwick, Sp. nova. Planta* volubilis. *Radix* haud visa. *Rami* longi, tenues, perdistanter foliosi. Partes maturae glabrae; ramuli tenelli, pedunculi et pedicilli capillis vacuis, pellucidis, multicellularibus vestiti. *Petioli* 15 mm excedentes. *Folia* 10 cm excedentia, lanceolata, sensim caudato-acuminata, glabra vel glabrescentia, nervis perobliquis, conspicuis, irregularibus. *Inflores-*

centiae interpetiolares, cymosae, aut distanter aut dense floriferae. *Pedunculi* 6 cm excedentes. *Pedicilli* aut longi aut perbreves. *Bracteæ et bracteolae* peranguste lineares, ad 5 cm longae. *Calyx* ad basim partitus; segmenta bracteis et bracteolis similia, semper corollam longe excedentia. *Corolla* 4 cm longa, in partibus apicali basalique inflatis 11 mm, in tuba 8 mm lata, colore (ut ex siccoexemplo videatur purpurea, lineis maculisque luteis veriegata. *Coronae* forma in exsiccato exemplo haud determinari potuit. *Folliculi* perangusti, 90 × 3 mm, cinerei, tenuiter striati; *semina* 8×3 mm; coma 20 mm, copiosum, molle.

Apud Sulgeri, in Canara, in Provincia Bombaiensi, ad alt. 500 ped angl., et pluv. circa 200 dig. angl. Coll. T. R. D. Bell, C.I.E. mense Augusto, id est in medio tempore pluviali, 1918; in herb. Sedg. et Bell. 4252.

A curious species, at once recognisable by the enormously long and fine calyx segments, bracts and bracteoles. The corolla is in general shape typical of the genus, the segments of the swollen apical portion meeting at their tips. The corona was quite indistinguishable in soaked out flowers.

Boucerosia truncato-coronata *L. J. Sedgwick, Sp. nova. Planta* carnosa, glabra, diffusa, ramis numerosis ad 15 cm altis. *Radices* crassae, succulentae. *Rami* 6 mm lati, supra haud attenuati, quadrangulares, faciebus alte sulcatis, et in angulorum tuberculis folia minutissima ovata ferentes. *Inflorescentiae* terminales, exacte unbellatae, (in exemplo viso) 13-florae. *Bracteae* 2·5 mm longae, lineares. *Pedicilli* 17 mm longi. *Calyx* ad basim partitus; segmenta 4 mm longa, linearia, acuta. *Corolla* tuba 6×6 mm, campanulata; limbo in aestivatione 5 segmentis triangularibus, valvatis exacte pentagono et in summo plano, 8·5 mm lato; (segmenta in anthesi utrum erecta sint an patentia haud satis notum, sed, at videatur, erecta); extus viridis, sed in limbo paullo purpureo-maculata, intus purpurea, vel prope nigra, fossiculis numerosissimis, luteis, pellucidis, linearibus, quae in cincturis interruptis dispositae sunt, insignata; inter segmenta in sinibus paucas particulas clavatas ferens. *Androecium cum gynoecio* parvulum, in corollae basi situm. *Antherae* quadrato-oblongae, obtusae, supra stigmatis discum incurvatae, approximatae sed non contiguae, in dorso sulcatae, colore luteae. *Pollinia* in cellulis solitaria, luteorubra, compressa, erecta, sed latere caudiculis minutis ad translatorem erectum purpureum affixa. *Corona* staminalis, duplex, crassa, ut corollae interior pars colorata; lobi exteriores 5, truncati, sed in utroque latere minutissime cornuti; interiores ligulati, elongati, adscendentes et in antherarum dorsales sulcos appressi. *Folliculi* haud visi.

In arido colle, sub fruticibus diffusa, apud Hubli, District Dharwar, in regione Carnatica Provinciae Bombaiensis, ad alt. 2000 ped. angl., et pluv. 30 digit. angl., mense September, 1919 ; coll. ipse.

An inconspicuous plant with elegant flowers. Differs from the other Indian species in having the bifid corona lobes reduced to a broadly truncate top with minute horns or teeth at each end.

Canscora stricta *L. J. Sedgwick, Sp. nova. Herba* inconspicua, erecta, ad 15 cm. alta, stricta, cauli quadrangulari, simplice, supra medium ramos strictos, secundos gerente. *Folia* haud visa, in autumnali tempore mox decidua ; folia quae ramos subtendunt auguste lanceolata, peracuta, 15 × 3 mm. *Bracteae* angustissimae, secundae ; bracteolae lineares vel etiam subulatae, secundae. *Flores* pro rata magni, cymose dispositi in ramis, aggregati, secundi. *Calyx* 7 × 1·5 mm.; tuba 5 mm. longa, striata, haud alata ; dentes 2 mm. longi, lineares, erecti. *Corolla* rosea, 10 mm. longa ; tuba 5 mm. lobi 4, in aestivatione imbricati, uno exteriore, vix contorti, valde inaequales ; 2 majores orbiculares, 2 minores oblongi, obtusi. *Stamina* 4, subaequalia sed unius filamento in corollae tuba paullo altius affixo, et supra decurvato : antherae subaequales, 2 mm. longae, subversatiles. *Stylus* filamentis longe excedens, stigmate breviter bilobato. *Ovarium* oblongum, angustum. *Capsula* cylindrica, 3 × 1·5 mm., nigrescens ; semina irregulariter polygona, nigrescentia. (See fig. p. 131.)

In saxosis planis intra nemora, apud Castle Rock, in District North Kanara, Provinciae Bombaiensis, ad 1600 ped. angl. alt., et circa 200 dig. angl. pluv., collegerunt T. R. D. Bell, C.I.E. et L. J. Sedgwick, mense Decembre A.D. 1917. Herb. Sedg. et Bell. 3393.

A member of the flora found on sheet rock in forest clearings. Differs very materially from all other Bombay species in the very simple, strict, erect habit with crowded, narrow bracteoles and flowers ; the calyx neither winged nor keeled but striate. One or two very small broadly ovate leaves were found on the stems ; but as these are almost certainly not typical vegetative leaves they were excluded from the description.



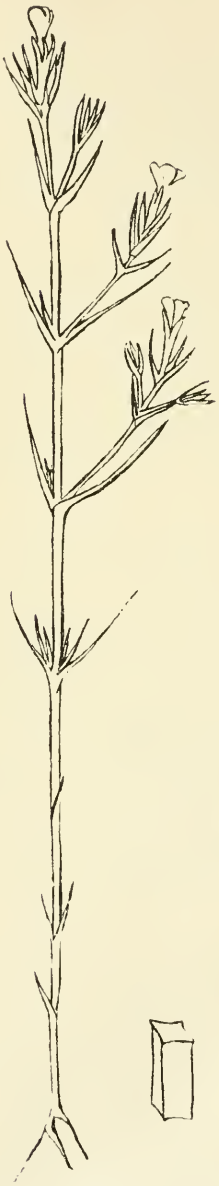
CHRISTISONIA FLAMMEA *L. J. Sedgwick*

P. F. Fyson & E. Z. McFie del. *Nat. Size.*



PHYLLANTHUS TALBOTI, *L. J. Sedgwick*

P. F. Fyson & E. Z. McFie del. ½ *Nat.*



CANSCORA STRICTA *L. J. Sedgwick*

P. F. Fyson & E. Z. McFie del. *Nat. Size.*

THE INDIAN SPECIES OF ERIOCAULON *

By P. F. Fyson, M.A., F.L.S.,
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The investigation of the Indian Species of Eriocaulon on which the following account is written arose out of the difficulty found in determining some of my own collections in South India, which led me to examine the collections in the herbaria of the Royal Botanic Gardens, Calcutta, and at the Agricultural Station, Coimbatore (Madras), and subsequently in those of the Peradiniya Gardens, Ceylon, the Forest College, Dehra Dun, and the Agricultural College, Poona, for types not found in the two former.

From an examination of the sheets in the Calcutta herbarium it was soon clear that other collectors besides myself have found the identification of species difficult. As far as India is concerned there are, if we exclude local Floras which have largely followed the F.B.I., only two works in which descriptions of the species are given: Hooker's Flora of British India, Vol. VI, (1894) and Ruhland's monograph in Engler's Das Palanzenreich (1903). The former of these is naturally now incomplete, being without species which have been founded since its date. The latter is not available to the ordinary botanist, and even if it were is, since it contains all the species of the world, too cumbersome for the collector. It is therefore thought that a revision of the Indian species accompanied by illustrations would perhaps be welcomed by collectors of this interesting but difficult genus.

It may not be out of place in this connection to note that the identification of a species from its published description alone is nearly always fraught with some, often with very grave risk of error; and that only by reference to the actual type sheet can certainty be attained. None of the species of this genus were, as far as I know, founded in this country, so that the actual specimens from which they were described are not here but in Europe. We have however in this country duplicates of many of the type sheets, and though the possibility of

* This paper was accepted by the editor of the Records of the Botanical Survey of India in September, 1918, but owing to congestion of work for that periodical is by his permission now printed here. A preliminary abstract appeared in this Journal, Vol. I, p. 49.

error in the duplicates is not excluded, it is not unreasonable to accept them as identical with the types. Kurz made, certainly, on a sheet in the Calcutta herbarium a note to the effect that the label must be wrong and that most of them seem to be wrong, but the latter part of the remark appears to me unduly pessimistic for with most of the sheets there is strong internal evidence of their correctness. There are however some species which I have not been able to trace, especially those founded by Ruhland, the types of which are persumably in Berlin. While therefore there are several forms which appear to be new species, they may not be so in reality. My new species are therefore advanced tentatively and with the object of avoiding the confusion which would inevitably follow a mistaken identification.

The illustrations given herein are mainly from photographs of herbarium sheets, and wherever possible, of the actual types or co-types of the species. It is hoped that this will make identification easier and more confident.

In the descriptive portion I shall as a rule give references to the Flora of British India and Ruhland's monograph only, and shall omit all synonyms, since the ordinary collector does not need them. But for reference in herbaria I shall give in Appendix II the identification marks and previous namings of all the sheets seen by me (practically all those in India and Ceylon) under the true species-name, as believed by me, and those interested will find the synonyms there. The usual enumeration of the collectors and their marks, in connection with the distribution of each species, is (with this appendix) unnecessary and has been omitted.

Following the name and the references, I refer (in the usual place) to the type sheet or its duplicate whenever I have seen this. If the type has not been seen no reference is made as a rule to any sheet. My authority for the name will be found in the appendix.

I tender my most grateful thanks to Lt.-Col. Gage, I.M.S., at the Royal Botanic Gardens, Calcutta; to Rao Bahadur K. Rangachariar of Coimbatore; to Dr. Burns and Mr. R. K. Bhide of the Agricultural College, Poona; to Mr. R. S. Hole of the Forest College, Dehra Dun, and to the Dr. Petch of Ceylon for very kindly lending me all the collections under their charge for examination; and to Col. Gage in addition for lending me reference books. I am the more indebted to them since on account of military duties my work was so often and lengthily interrupted that I had to keep the sheets far longer than I had expected, the work being begun in the autumn of 1917. To Mr. Streenivasiah, my herbarium-keeper, I am also gratefully indebted for much assistance, and he prepared nearly all the photographs,

Introduction.

The ERIOCAULACEÆ are a very distinct family of flowering plants which in one respect occupies among the Monocotyledons a position analagous to that of the COMPOSITAE among the Dicotyledons The flowers are very small and aggregated into a head, which is enclosed at first and subsequently backed by a involucre of outer bracts. Unlike the COMPOSITAE the flowers are unisexual, and are typically complete in every other respect, that is they possess complete whorls of sepals and petals, and either two of stamens or one of carpels. The genus Eriocaulon with its three sepals, three petals, and three carpels in the female flower ; and 3 sepals usually united into a spathe-like calyx, a trumpet-shaped 3-lobed corolla and 6 stamens in the male, comes nearest to the monocotyledonous type : but we find two-merous flowers in some species ; and in some, otherwise trimerous, two sepals only, or two or fewer petals, obviously by reduction.

The genus was founded by Linnaeus in 1742, and subsequently placed by Kunth along with one or two related genera as a tribe of the order RESTIACEÆ. Martius, reviewing this tribe in 1835, raised it to the rank of a distinct order, the Eriocaulonaceæ, a name afterwards changed by Richard to ERIOCAULACEAE. Koerniche wrote a monograph with very full descriptions and several new species in 1856.* Steudel gave short descriptions of all the known species in his Syn. Pl. Cyperacearum in 1858 and other authors, notably Sir J. D. Hooker, have founded species in "Floras" of Ceylon, India, Tropical Africa and Brazil. In 1903 there appeared in Engler's Das Pflanzenreich a monograph by Ruhland of all the species known in the family, with several new ones founded by him. The number of species described was 420, of which 200 belonged to Paepalanthus found only in America, and 193 to Eriocaulon. The latter genus is distributed all over the warmer parts of the world, being found in America, Africa, Asia and Australia, and even in Europe as far west as Ireland. But although there are in India some fifty species, occurring over the whole of South India as for North as Mount Aboo and the Central Provinces, and along the Himalayas from the eastern end to Dehra Dun, there are no collections from the United Provinces or the Punjab. In India therefore excluding the Himalayas, the genus is confined to the tropics.

Most species of Eriocaulon grow exclusively in wet places, a few only fully submerged, and only one or two I believe in ground always dry enough to be firm. It has long been recognised that the conditions of water and marsh are much more uniform the world over

* Linnaea, Vol. XXVII.

than those of dry ground; and it is therefore not surprising that there is a sameness about the vegetative parts which we do not find in dry land plants. Thus in Eriocaulon the stem is nearly always very short, little more than a flat disc, with the leaves all radical and narrow, and the flower-heads are carried well above the ground or the water-level on tall scapes. There are of course differences; submerged species have linear leaves, and some have elongate stems: some land species are hairy, most glabrous; in some species there is only one, in most there are numerous scapes: but except for these the differences are mostly small and difficult to define. This sameness in the vegetative parts is accompanied by a surprising amount of difference in the floral, on which therefore the separation of the species is of necessity largely based. But since the parts are always very small and need a good lens for their study the species are difficult to diagnose, and in most cases it is impossible to do so with the naked eye without considerable practice. Collecting therefore, for any one not thoroughly conversant with the species, is like pulling things out of a bran-tub, one cannot tell at once what one has got; and the determination of the species afterwards, unless the descriptions are very clear and to the point, is difficult in the extreme. This is borne out by an examination of the material in the Indian Herbaria. Thus six collections made by Meebold in Mysore and Coorg, from September 1897 to November 1898, of what is certainly one species, were named by him, *E. sexangulare* three times, *E. truncatum* twice and *E. trilobum* once. Yet these three species should never be confused, and the plants collected did not as a matter of fact belong to any one of them. The name *E. sexangulare* I find wrongly given on 15 collectings in the Herbarium of the Royal Botanic Gardens, Calcutta, belonging to seven species quite distinct from the true *E. sexangulare* of Linnaeus; and *E. luzulaefolium* to 13 collectings belonging to six species, four of them being among the seven just referred to; and these are not exceptional cases; the third column of the Appendix will show that 2 species have each been given names of 7 other species, 2 more names of 6 other species, 7 of 3 or more other species.

One result of this is that species have been given a wider distribution than they are entitled to, and this has of course led many a collector to suppose that he may have a species which really does not exist in his area. Especially is this the case with *E. luzulaefolium* Linn. which has been reported as all over South India, from Khasia to Bombay, Madras, Malabar and Ceylon. But, unless the sheets which bear Wallich's number in the Calcutta Herbarium do so wrongly, the species is confined to Nepal, Assam, Bengal and Upper Burma.

The Arrangement of the Species.

As far as the Indian species are concerned, if we except the local floras founded on the F.B.I. there are, as stated above, only two modern works giving descriptions, the F.B.I. and Ruhland's monograph of the whole family. Previous to this excellent descriptions were given by Steudel (Syn. Pl. Cyperacearum 1858) and Koerniche (Linnæa XXVII, 1854, pp. 577-692).

The species are arranged in these two works on entirely different plans. Hooker after separating the purely aquatic and submerged forms, divided the remainder according to the external appearance of the heads and the presence or absence of hairs on the receptacle. Ruhland on the other hand arranged the species according to the number of parts in the flower, placing in his first section, which though he does not so identify it I take to be NAYSMITHIA Huds., those with 2 parts to each whorl, in his second section those with 3 parts, and in his third those with 3 parts in the staminal and carpellary whorls but with fewer sepals or petals; these sections being further divided for convenience into the eastern or old-world species and the western or new-world. He then took the nature of the stem whether disciform or elongated, with such characters of the flower as white or black anthers, crested or plain sepals, for the lesser divisions. The difference in the two systems is very great. Two plants classed by Hooker as dimerous and trimerous varieties of the same species, *E. sexangulare*, appear in Ruhlands monograph, as also in Steudel's Syn. Pl. Cyp., in different main divisions of the old world species, and in the former's list as numbers 25 and 186 respectively. The plant named by Trimen *E. atratum* Koerniche var. *major* was raised by Hooker to the rank of a species, *E. caulescens*, and placed next to *E. robustum* Steud. of the Nilgiris, from which it hardly differs except in having a tall and branched stem; whereas Ruhland separated the two by no fewer than twelve Indian species, and placed *E. robustum* next to *E. quinquecangulare* Linn., which in Hooker's arrangement is separated from it by almost the whole of the Indian forms, one being No. 4 and the other No. 35 out of 43.

It would probably be correct to state that except in his main divisions Ruhland in fact did not attempt to arrange the species in phylogenetic groups, but only to provide a general clavis for aid in their identification. Hooker made tentative groupings, but apart from the separation of aquatic from terrestrial species made no definite sections.

Before attempting to classify the species of a genus it is clearly necessary to determine what characters if any are liable to vary with age or with the conditions of the environment, and further

to estimate if possible the relative importance from the phylogenetic stand-point of the more stable characters.

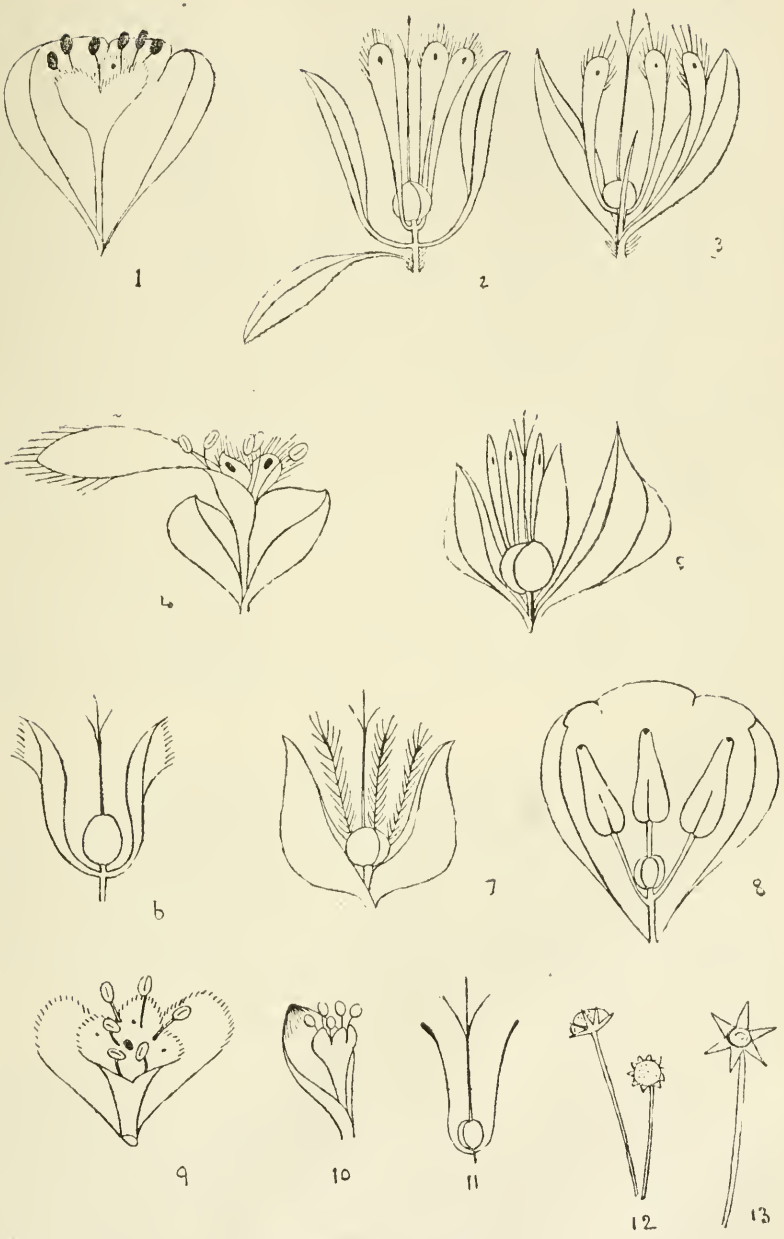
Stem and Leaf.

As said above since practically all the Eriocaulons grow either in swampy ground or submerged in water the stem and leaves of any one species vary but little, even in size. At the same time all submerged forms are for a like reason so alike among themselves, and the swamp forms also among themselves, that such differences as exist are of little use in separating the species. The difference between the usual disc-like stem, and an elongate branching one, which Ruhland following Koerniche used almost at the fore-front of his clavis of old-world species, though at first sight it may seem very definite, is not always a hard and fast line, and is in any case probably bound up with the robustness of the species and the nature of its habitat. As instance the Nilgiri *E. robustum* and the Ceylon *E. caulescens* referred to just above. But I have found the former with root-stock over on inch in length, and poorer specimens with leaves narrow enough to be indistinguishable from those of the Ceylon plant. In Ruhland's list one is No. 74, the other No. 120.

The Head and its Involucre.

As regards the heads Koerniche used the difference of hairy and glabrous involucre, as also did Hooker and Ruhland ; and without doubt this character is of sectional value. But I find the hairiness varies and may even be absent from a plant undoubtedly for other reasons allied to hairy species. This character must not therefore be used two rigidly, as in Ruhland's wide separation on this account of *E. Brownianum* Mart. from *E. nilagirense* Steud. (Nos. 93 & 117 respectively.) The specimens in Herb. Calc. show plainly that the type sheet of the former is of a not fully undeveloped plant and that the absence of hairs is here accidental.

Characters which give very distinctive appearance to the head and would certainly appear at first sight of at least *specific* value are afforded bythe form and length of the involucral bracts. Thus they are horizontal and very obtuse and slightly turned up at the end in *E. sexangulare*, *E. luzulaefolium*, *E. truncatum* and *E. Thwaitesii* ; they are acute and ultimately reflexed in *E quinquangulare* and *E. trilobum*. In *E. xeranthemum*, *E. roseum*, *E. martianum* Wall. and forms of *E. Dianae* collected in Coorg, they are very much longer than the head, projecting beyond the general margin like the rays of a sun-flower. (Pl. fig. 12 & 13.) Koerniche placed great value on this. But a comparison of a large number of collections made on the Western Ghats from Salsette to Calicut, all with the same flower,



TYPES OF FLOWER.

show that the last named species is extremely variable in this respect, every intermediate form being found from large conical heads with short reflexed bracts to small flat heads with long bracts. It is clear therefore that, at least with this species, the relative length of the involucral bracts is of varietal rank only. But if this be so then perhaps it is also with other species; and the peculiar Burmese plant *E. Martianum* Wall, should be considered a variety of *E. quinquangulare*, not as either a distinct species or a proliferous of state (*cp.* Hooker (1) *p.* 582.) A similar but less pronounced lengthening of the involucral tracts appears in two other species, in other respects widely separated, *E. gracile* Mart. and *E. cuspidatum* Dalz. At the same time extreme variation of this kind should probably be considered specific—e. g. in *E. xeranthenum* Mart. and *E. roseum*, as also of course when accompanied by differences in the flowers (*E. Edwardii*). But it is clear that the form and length of the bracts is not in itself of 'sectional' ranks as Koerniche supposed.

The colour of the involucral bracts is some guide, as in the separation of what I take to be *E. atratum* Koern. from *E. subcaulescens* Hook. f., but it is an uncertain one, the black colour fading often out of these bracts with age. On the other hand the scarious, usually straw-coloured, floral bracts of some species are easily distinguished from the more common black with white hairs. The difference is definite, with no merging, and I take it to be of 'sectional' value. Black bracts are usually hairy and scarious bracts glabrous, but there are exceptions.

Hairs on the receptacle are a constant feature of most species, but are partly or altogether absent from others; and Hooker made use of this in the F.B.I. This difference accompanies others of 'sectional' rank, but may occur inside the section and is I believe of only secondary importance. Another character to which Hooker gave some importance is the length of the pedicel (stipes.) I am not able to follow him in this. The length appears to me to depend on the age of the individual flower, and to be therefore of no importance.

The Flower, its Petals and Stamens.

It is in the flower itself that the greatest differences are found. In the male the chief distinguishing characters are white or yellow instead of black anthers, and one corolla-lobe being so much longer than the rest or to protrude beyond the floral bracts and cover them. The first gives an absolute line, not in any way bridged over by an occasional species with olive-green colour. Ruhland stated (lc. p. 16) that the colour is constant in the species, but used this difference more than once in his clavis as if of only minor importance. Hooker

did not notice it at all. Steudel and Koerniche were both aware of this difference, but neither paid any particular attention to it. Apart from the improbability of so very definite a change as the loss or acquirement of the black colour happening more than once, yellow anthers are so distinctive that I have no hesitation in making a 'section' of the species which possess it. The protruding male petal is also a very distinctive character and one naturally used in any scheme of classification. It appears to be a very constant character, and nearly all the species which show it do so quite definitely. But as might be supposed indications of the habit are not wanting in other species, some of which may therefore be regarded as on the line of development. The stamens do not vary in number. They are always six, except in the one dimerous-flowered species.

In the female flower the ovary is invariably 3-lobed (except of course in dimerous flowered species)—there is no reduction. The petals are 3 or 2, and only slight differences occur between those of different species; except in one direction. As a rule they are oblanceolate, with thick terminal hairs and slender, longer, lateral ones; but in some species there is a brush of slender filaments or hairs, which might be regarded as due either to the longitudinal splitting of the petal into many parts or to a narrowing of the petal accompanied by an increase in the number and length of the basal hairs. This latter change may well have come more than once, in different groups, I therefore do not use it as a 'sectional' characteristic.

The Sepals.

The sepals shows the most interesting variation. The simplest probably primitive, form is boat-shaped, black in colour and with a few hairs along the mid-rib or keel. In one Himalayan species the sepals are connected into a calyx similar to that of the male flower. The petals of this species differ from others in having the gland terminal and in being clawed. Ruhland has a group of Chino-Japanese species with these character, I therefore found my section CONNATO-SEPALAE to include them. In all other species the sepals are free. A development of the boat-shaped sepal is the formation of an enlargement (a thickening, wing, or crest) along the keel. In some species this takes the form merely of a thickening (*E. Thomasi* Pl. I. fig. 7) in others of a narrow wing or crest which may be lobed, or pectinate (figs. 5 & 6.) The depth of the thickening or crest appears to vary in the same species but there is usually no doubt about the crest when it is present. I therefore make a 'section' of those species which possess this enlargement, whatever its precise form may be. Here again it may be that *E. sexangulare*, *E. cuspidatum* and *E. Thomasi*, are not derived

from the same proximate stock as *E. Elenorae*, *E. Margaretae*, and *E. minutum*, through all show this character. The question could be decided only after examination of extra-Indian species.

These three types of sepal : the united, the boat-shaped and the crested, are quite distinct ; the only specific difference being that in the latter two the three sepals may not be equal in size, and one may be flat instead of boat-shaped, or without the crest. But in the species which show these exceptions individual variation does occur Thus in *E. Elenorae* the relative sizes of the 3 crested sepals varies, two may be of a size, one smaller, or the three all unequal, or one the smallest without a crest. These variations are shown in plants otherwise indistinguishable. They are therefore not of specific value. I am doubtful indeed whether *E. Elenorae* where the sepals are unequal should really be separated from *E. Margaretae* (were they are all alike), but the species are slightly different in appearance, and I have found no variation in plants with the 3 sepals equal (*E. Margaretae*). So also in those with two sepals boat-shaped, one not. The odd sepal in *E. Dianae* may be lanceolate and as long as the other two, or shorter and bristle-like, or so slender that it is difficult to see.

We have in both these lines apparently a reduction in the size of one sepal till is nearly disappears, and if this be so a species with only two sepals may be derived from one with three. An instance where this has actually and unmistakably occurred even inside the species is afforded by *E. Xeranthemum* Mart. Hooker in F.B.I. gives the female sepals as 2. I find plants on the Himalayas have 2 sepals, but some at least on the Malabar coast have 3. Ruhland says that the sepals are 3, unequal. No one seeing the plants would wish to make several species of them. The same occurs in *E. truncatum* where the sepals may be 3, but are usually 2 only, and in the same plant I have found 3 equal, 2 and 1 smaller and 2 only ; and also in *E. Thwaitesii* Hook. f.

We are thus faced by a set of conditions which must be unique among flowering plants. No other case is known to me of a reduction in the relative number of sepals and petals within the species of genus, though the number may be indefinite—*e.g.* in species of *Ranunculus* and *Jasminum*. The stamens certainly show a reduction in some genera (*e.g. Cassia* and *Bauhinia*), and occasionally between the genera of family (*e.g.* Caryophyllaceae, Acanthaceae), but even this is not common. Characters in fact which in all other phanerogamic families are so constant as to be of the first importance in determining families and cohorts here vary even within the species, and so are of no use at all as guides to the phylogeny.

The Sections or Main Groups.

The following deviations from what might be called the normal or primitive conditions seem to be the most constant—hairy involucre, one male petal enlarged, scarious floral bracts, crested female sepals, united female sepals, and white anthers; while the number of sepals or petals, in either sex, their relative sizes and shapes, the length of the involucral bracts and of the pedicels are not necessarily even of specific rank.

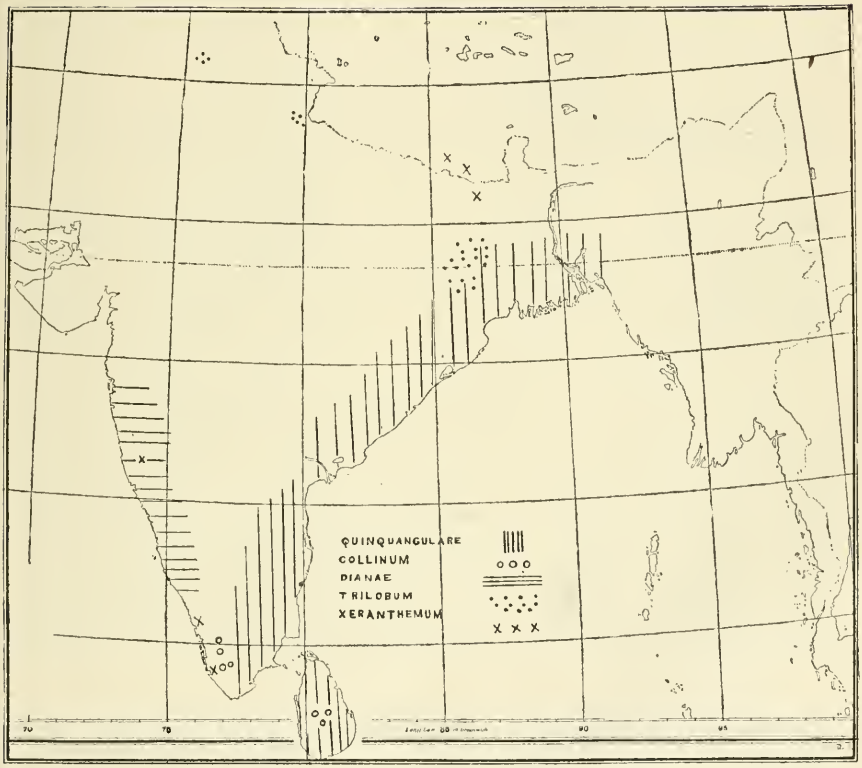
If this supposition be correct, and the evidence is I think too strong to doubt it, the Indian species fall naturally into eight groups distinguished by the above 'sectional' characteristics, with a ninth composed of species or forms which grow wholly submerged in water and have elongated stems thickly covered for several inches with long capillary leaves. This group I name SETACEÆ, from the chief and Linnaean species; not, following Hooker, *Aquaticae*, because there are other species with just as good a claim to that title. A character which like this is purely adaptative is not as a rule considered of much value in determining relationships, but the five forms which share this in common are so alike among themselves and so different in appearance from any other species that they must go together in any systematic scheme. The possibility is not excluded that they have sprung severally from the other distinct sections of the genus, but the fact that the male sepals are more or less free instead of being united into a calyx split at the back as with most of the other species, may indicate that they separated off early from the primitive stock. Of my other eight sections the ANISOPETALÆ with one male petal much enlarged, and the HIRSUTÆ with hairy involucre, correspond in part to groups in the F.B.I. of species with these characters but not so named. The LEUCANTHERÆ with white or pale yellow anthers, the CRISTATO-SEPALÆ with crested female sepals and the CONNATO-SEPALÆ with the female sepals connate, found places in Ruhland's arrangement; but, except the last of which there is only one species in India, were broken up in the different claves and included several species which I exclude. The SCARIOSÆ with scarious floral bracts is I believe a new grouping; and I place together as SIMPLICES all species which do not show one or other of the above mentioned characters.

Geographical Distribution.

The geographical distribution of the species and groups presents many interesting problems of variation and relationship. As regards the extra-Indian species, the material at my disposal does

not allow me to say very much; but certain general conclusions may be drawn from an examination of the very full and careful descriptions of the flowers given by Ruhland in his monograph. It might be supposed at the outset that since the plants grow in water and marshy ground their seeds would be carried on the feet of migrating birds, and that this, coupled with the universally accepted similarity of the conditions of water and marsh the world over, would result in a very wide distribution of most of the species. Some certainly are scattered widely, but the majority seem to be confined to comparatively small areas. This question is of course bound up with that of the limits of the species: thus *E. Sieboldianum* Sieb ot Zucc, as understood by Hooker in the F.B.I., occurs all over S. E. Asia from Bombay to Japan and N. Australia; but Ruhland separating from it several smaller species gives to them a much narrower distribution, though he retains almost as wide a one for *E. Sieboldianum* itself. Of the groups which I have proposed in this account the SETACEÆ group has one representative, *E. bifistulosum* Van Huerck, in West Africa and probably others elsewhere. The SIMPLICES being all those with no special modification of the floral parts are no doubt primitive and world-wide. The HIRSUTÆ and ANISOPETALÆ are spread over S. Eastern Asia from Cochin to China, probably on the mountains of the warmer parts, and the latter seem to have a second centre of distribution in British Guiana. The CRISTATO-SEPALÆ also seem to have a centre in tropical South America, reaching from Mexico to Brazil. But the CONNATO-SEPALAE, which have in India only one representative on the Himalayas, belong almost entirely to China and Japan. Of the LEUCANTHERAE one species, *E. Sieboldianum* Sieb. et Zucc, is widely spread over tropical S. E. Asia, Malaya and Australia, but the others seem confined to India. *E. Sieboldianum* is probably the most widely distributed of all the species, and *E. Brownianum* Mart. with its varieties (or related species of Ruhland) covers almost as wide an area.

Inside India there appear to be on the plains and lower hills no species at all north of a line from Mt. Aboo to Dacca, and not many northwards on the Himalayas, though there are one or two in Kashmir. They occur all over South India. The HIRSUTAE belong almost entirely to the mountains above 3,000 ft. of Burma, Bengal, S. India and Ceylon, but extend far southwards to Singapore. The ANISOPETALAE are developed chiefly in Ceylon, with one species in Bengal, one in the Central Provinces and the Deccan and another on the Niligiris; but not curiously enough collected hitherto on the Palnis which are nearer Ceylon and floristically show closer affinities. Of the CRISTATO-SEPALÆ the smaller species belong to the Western



Map 1. Showing the distribution in India of certain species of the section Simplices.

Mountains from Mt. Aboo to Coorg, but do not go further north, east or south.

The group *collinum-quinquangulare-trilobum-Dianae*, has collectively the widest distribution, and shows very interesting developments and cross-relationships. *E. quinguangulare* belongs to the plains of Ceylon, S. India and the Deccan, extending only rarely to the Western side in Canara. On the mountains to the south it is replaced by *E. collinum* Hook. f. and to the north in Bengal by *E. trilobum* Ham., both of which hardly differs from it except in the much darker head and better developed sepals, but are really quite easily distinguished. *E. quinguangulare* and *E. trilobum* have their counterpart on the wastern side in *E. Dianae* Sp. Nov. which in its widely differing varieties is similar to both, but differs in the reduction of one sepal to generally only a bristle and in the involucral bracts being usually longer. *E. collinum* has likewise in Ceylon one sepal smaller than the others, but the forms are not otherwise distinguishable. Both *E. quinquangulare* and *E. Dianae* show lengthening of the involucral bracts, though the former only in Burma ; and *E. xeranthemum* with sometimes 3 female sepals sometimes 2, might be derived from either. It is in fact as if the two species *E. quinquangulare* and *E. trilobum*, and perhaps also *E. collinum*, were originally one, and developed from it as varieties and later on species, in—(1) the plains of S. India : and L. Bengal, (2) Upper Bengal, and (3) the mountains of S. India : and further as if these have independantly suffered a reduction in one sepal of the female flower ; the first two in travelling westwards across the Ghats to the sea, the third in crossing over to Ceylon. Another change was a lengthening of the involucral bracts, which seems to have proceeded independently in both *E. quinquangulare* and the derivative *E. Dianae*, as it has done also in other species.

The Mendelian would doubtless find in crossing a sufficient explanation of these double relationships, but it remains that the species as here defined occupy distinct areas and are found together if at all only on the borders of contiguous fields.

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Herb. Dehra Dun.—Herbarium of the Forest College and Research Institute, Dehra Dun.

Herb Madras.—Herbarium of the Agricultural College and Research Institute, Coimbatore.

Herb. Presidency College, Madras.—Herbarium of the Presidency College, Madras.

Herb. Sedgwick.—Herbarium of Messrs L. J. Sedgwick, I.C.S. and T. R. Bell, now St. Xavier's Coll., Bombay.

Herb. St. Xavier.—Herbarium of St. Xavier's College, Bombay.

Herb. Talbot.—Herbarium of the late W. A. Talbot now at Ganeshkind with Herb. Bombay.

Terms used in descriptions.

Pale*—of the involucre or the floral bracts,—an absence of black, usually resulting in the bracts being straw-coloured when dry, but sometimes light-brown, sometimes white. When fresh they are in some, perhaps in all cases, scarious and translucent.

* The word pale may appear hardly suitable as a descriptive term, but I know no other that fits the care so well. For the bracts so termed are characterised not by the presence of a light coloured pigment, so that they cannot truly be called white or yellow, but by the absence of the more usual black; and being thin are translucent, but when dry straw-coloured.

Normal—of the flower—Sepals in the male united into a calyx split at the back; in the female 3, equal and similar. Corolla of male trumpet-shaped with 3 lobes; of female 3 oblanceolate free petals. Stamens 6, anthers black. Ovary 3 celled.

Eriocaulon Linn.

Linn. Gen. Ed. II 35 (1743).

Scapigerous herbs, aquatic or on marshy, rarely dry ground. Stem usually very short and disci-form, but in some species elongate and branched. Leaves narrow. Scape slender, with 4 to 7 ribs, twisted usually, and enclosed at the base in a sheath with oblique mouth. Flowers minute, each in the axil of a bract, in involucrate heads; unisexual, nearly always monoecious; perianth inferior. Male flower:—Sepals 2 or 3, usually, but not always, connate into a calyx split on the ad-axial side. Corolla mono-petalous, funnel-shaped; lobes 3, small, usually ciliate and each with a large black gland. Stamens 6, attached to the corolla; anthers black or pale yellow. Female Flower:—Sepals 2 or 3 flat, boat-shaped or crested, equal or unequal. Petals 3 to 0 free, linear, oblanceolate or spathulate, ciliate, each with a black gland near the upper margin. Ovary three-celled; style with 3 short branches. Carpels in fruit globose opening down the back to let out the one seed. Seeds translucent yellowish or brown, often with darker markings. Embryo minute, outside the horny endosperm.

Species about 190 in the tropics and rarely in temperate regions.

The above diagnosis is for the normal 3-merous flower. In one Indian species, the flowers may be dimerous with 4 stamens or a 2-celled ovary. But in the majority of species there are 6 stamens or a 3-celled ovary, even though the sepals or petals may be reduced to 2 or 0.

Scheme of Sections.

[Note the female flower may have no petals in groups II, V, VI and VIII.]

A. Anthers black.

* Submerged plants with and linear leaves.

I. SETACEÆ.—Stems to over a foot in length. Leaves 3-6 in. Head 1/8—1/5 in.

* * Terrestial or swamp plants, or if submerged the stem not more than an inch long. Male sepals usually but not always united into a calyx split on the side.

† Female sepals free, boat-shaped or flat, except in VII.

¦ Floral bracts usually black with white hairs on the back. Receptacle villous except in II a.

II. SIMPLICES.—Involucre glabrous. All floral parts in 3's. and equal or one female sepal smaller or absent.

(*a*) Receptacle ... glabrous.

(*b*) Receptacel ... hairy.

III. HIRSUTÆ.—As II b, but involucral bracts hairy, or also the scapes and leaves.

IV. ANISOPETALÆ.—As II b, but one male petal much enlarged and projecting so or to hide the floral bracts.

† † Floral bracts scabrid or puberous, pale: receptacle villous.

V. SCARIOSAE.—Female sepals 3 or 2 narrow. Male flowers normal.

VI. CRISTATOSEPALAE.—Female sepals strongly boat-shaped and crested on the keel or at least enlarged. Floral bracts puberous in some. Male flowers normal.

† † Female sepals connate.

VII. CONNATOSEPALAE.—Female petals clawed. Male flowers normal. One species only on Himalayas, remainder in China, etc.

B. Anthers white.

VIII. LEUCANTHERAE.—Involucre black or pale. Floral bracts usually dark with white hairs, but also light and glabrous.

General Key to the Groups.

a. Plants entirely submerged, leaves linear or ribbon-like b.
Plants of wet ground, leaves more or less lanceolate ... --- ... d.

b. Stem leafy for several inches; heads 1/6 in. or less SETACEÆ.
Stem O, or if longer and branched, under 3 in. c.

c. Anthers black, Ls. 1—2 in. (Khasia) E. gregatum or E. barbacaprae.
Anthers white or yellow stem O; ls. 2 in. or more LEUCANTHERÆ.

d. Anthers white or yellow Do.
Anthers black or greenish e.

e. { Floral bracts at least the lower, hidden by the projecting male petals ANISOPETALÆ.
Petals enclosed, or not projecting conspiciously beyond the bracts f.

f. { Heads white or grey by the hairs on the otherwise dark floral bracts g.
Floral bracts greenish or brownish, puberous, very closely imbricated. E. Sexangulare, E. cuspidatum, or E. Thomasi.
Floral bracts black, glabrous; female sepals connate (Himalayas) E. ALPESTRE.
Floral bracts glabrous, yellowish or scarious. h.

g. { Whole plant hairy, or heads over 1/2 in. diam. depressed HIRSUTÆ.
Plant glabrous or nearly so, heads globose or ovoid SIMPLICES.

h. { Female sepals boatshaped, two at least with a wing or crest CRISTATO-SEPALÆ.
Female sepals boatshaped or flat SCARIOSÆ.

(To be Continued.)

Explanation of the Figures—(See p. 159.)

Fig. 1. Male flower of *E. quinquangulare L.*
Fig. 2. Female flower of *E.* do.
Fig. 3. Do. do. *E. trilobum* Ham.
Fig. 4. Male do. *E. caulescens* Steud.
Fig. 5. Female do. *E. Eleanoræ* sp. nov.
Fig. 6. Do. do. *E. minutum* Hook
Fig. 7. Do. do. *E. Thomasi* sp. nov.
Fig. 8. Do. do. *E. alpestre* Hook. f.
Fig. 9. Male do. *E. horsley-kundæ* sp. nov.
Fig. 10. Do. do. *E. Sieboldianum* Sieb et Zucc.
Fig. 11. Female do. *E.* do. do.
Fig. 12. Head of ... *E. Dianæ* sp. nov.
Fig. 13. Do. ... *E. roseum* sp. nov,

CURRENT LITERATURE.

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Histology.

Gates, R. Ruggles. A preliminary account of the meiotic phenomena in the pollen mother-cells and tapetum of lettuce (Lactuca sativa). *Proc. Roy. Soc. London, B. 91 : 216—223. 2 figs. 1920.*

The material under investigation is an improved variety of lettuce, and a "rogue" arising from it. The two plants agree in details of reduction, and show certain striking deviations from the usual normal behavior of pollen mother-cells. In the first place, every gradation was observed between tapetum and mother-cells. The tapetum become bi-, and in some cases tetra-nucleate. At the mitosis of the binucleate condition a few instances of typical synapsis have been observed. This is taken to mean, not that tapetal cells are degraded spore mother-cells, but that synapsis may be merely a physiological "phenomenon of the nucleus which might be directly induced in any diploid cell if it could be placed under the proper conditions." It is believed that synapsis has never before been described for other than spore mother-cells.

In mother-cells during the synapsis stage, extrusion of chromatin material occurs when the nuclei lie so for to one side of the cell that they touch the cell walls. At diakinesis there are nine bivalent chromosomes, among which constant differences in length are found, some being very long, some intermediate, and some almost spherical. Just before the bivalents begin to shorten and thicken, the constituent chromosomes of many are found to be variously looped or wrapped about each other, in some cases so intimately as to suggest than an interchange of segments may occur when they break apart. This is thought to be the first time such a process of chromosome fusion has been described for plants, though the appearance has been figured by other investigators.

A few cases of what appeared to be end to end fusion of bivalents was observed, making eight instead of nine pairs of chromosomes in the nucleus. Later, when the chromosomes are arranged on the equatorial plate, all the bivalents become so greatly condensed that they are practically spherica. And here also is observed a tendency for one or two pairs of bivalents to coalesce, resulting in eight or even only seven distinct chromatin masses. All gradations of coalescence are found between this and nine distinct bivalents. This feature also is thought not to have been described before, either for plants or animals. The suggestion is made that such a fusion of bivalents "furnishes a possible basis for the phenomenon of partial coupling or repulsion, apart from the 'crossing over' phenomena, which are based on relations between the two members of a pair of chromosomes in their earlier post-synaptic stages."

Finally, the substance of the mother-cells is divided into tetrads of spores by invaginations, as in animals, regardless of whether the spindle fibres persist or have already disappeared. No cell plate formation in the usual manner has been observed. As the pollen grains are maturing, the tapetal cells disorganize into a tapetal plasmodium, a condition regarded as uncommon for angiosperms.

The paper leaves one with the feeling that the author has distinctly furthered our knowledge of the process of reduction, and of the mechanics of heredity. The closing sentence is one the spirit of which might well be taken to heart by all engaged in scientific investigation ; " it is considered that the study of variations in the behavior of the chromosomes has been too much neglected, and that any account is incomplete which does not include a record of the conditions rarely or infrequently observed, as well as of those which seem to fall into the usual order of events."

W. D.

Distribution.

Hitchcock, A. S., Floral aspects of the Hawaiian Islands. *Annual report of the Smithsonian Institution, 1917. p. 449.** (Just received).

This is a semi-popular account of the flora of these islands and contains much interesting matter. The writer is much struck with the number and variety of ornamental plants which he met at Honolulu, practically all of foreign origin. He states indeed that at least on the plains, the native flora has been almost exterminated by introduced plants, many of them weeds. This is in accordance with Charles Darwins expectation of the superiority of continental and widely distributed species over those of a small area. Among these introduced plants are several species familiar to us in Indian gardens, *e.g.*, Cassis fistula, C. nodosa, varieties of Hibiscus, Acalypha, Aralia and the common Croton (Codiæum variegatum) and of course the S. American Bougainvillea. The islands have not escaped those pestiferous weeds, Opuntia, and Lantana, but Acacia farnesiana and Lucæna glauca, though introduced some years ago and throughly naturalised have not become troublesome. Coming now to the natural or indigenous flora, the most striking are the giant Lobelias, of which there are as many as 100 species, some attaining a height of 40 feet. Ferns of all sizes abound, the tree-ferns running up to even 30 feet, though usually shorter. What is apparently a strongly zerophytic plant is the " silver sword". Argyroxiphium sandwicense, which has numerous sharp pointed leaves covered with silvery-white closely appressed wool. The plants grow in dense tussocks from a few inches to two feet in diameter, on cinder cones and other arid spots, and in the distance look like sheep. Similar tussocky plant are common in other desert regions. An interesting feature of the flora is the poverty in species of certain world-wide families. Thus there are practically no orchids. only three small terestrial and rare species being known ; the palms are represented by ten species only of the single genus Pritcardia ; the Melastomaceæ are entirely absent though so abundant in tropical America ; and the Compositæ and Labiatæ, large universally distributed families, and the former usually abundant in mountainous country, have only a few species. Considering the tropical position of the islands, and the large climatic differences caused by the presence of mountains

running up to over 13,000 feet and of a rainfall which varies from 15 inches at sea level to 600 at 5,000 feet, the virtual absence of these families is very striking, and illustrates the smallness of range of seed-distribution by natural means.

P. F. F.

Lewis F. Notes on a visit to Kunadiyaparawita Mountain, Ceylon. *Jour. Linn Soc. xlv. No. 302.** 9*s*.

The object of this paper is to "draw attention to the influence upon plant distribution of very special environment." The mountain is cut off from all those round it by very deep valleys, and the summit may be regarded as an elevated island, of 5000 ft. altitude, in a sea of forest. It meets with the full force of the S. W. monsoon, but during the N. E. the air is very calm. The flora of the summit is entirely endemic, there being no introduced plants, though these are so common in other parts of Ceylon, at the same elevation. And the endemic flora is not typical of such elevations. Thus the common Rhododenron is entirely absent, and a Kendrickia sp. growing 20 miles away in a broad belt between 3000 and 4500 ft., is here confined to between 4000 and 4500 ft. The author thinks that the steepness of the slopes by preventing heavy seeds and fruits from lodging or finding a foothold, the strong wind and humid atmosphere, and the inaccessibility of the mountain to human beings, has been the cause of the freedom from plants of other countries; and that "a high percentage of endemics may always be associated with exceedingly steep mountains and that the narrowness of the vertical distribution in these instances is attributable to physical conditions of preponderating power."

P. F. F.

Wilson, E. H., Notes from Australasia No. 1 *Jour. Arnold Arboretum II, 3.** $1.

This is a short but graphic account of the vegetation of Australia south and east of Fremantle. We are reminded at the outset of the enormous difference between the flora of this continent and of the old or the new world. "The remarkable Grasstree (Kingia) and the Blackboy (Xanthorrhoea) of Western Australia, probably of an earlier flora than any other living trees, seem out of place in the absence of pachydermous animals and the presence of the extinct gigantic Saurians of the Jurassic age would be in keeping with these strange and ancient types of vegetation."

The southern part of Western Australia "is a veritable botanical garden crammed with an astonishing variety of plants bearing a wealth of curious flowers of intense and vivid colours". Herbs we read are comparatively few, but there are gigantic Droseras. The shrubs when not in flower are strongly alike, because of their narrow or spiny leaves, and are mostly Proteaceae with Callistemons and others, all with gorgeous flowers. All the large trees are species of Eucalyptus, the smaller of Casuarina, Mellaleuca, Hakea etc. There are only four climbing plants and they are slender. The Eucalyptus are really wonderful trees. E. Salmonophloia grows, rooting only near the surface, to a height of 100 ft. and a girth of 10 ft. with a rainfall of only 5 to 10 inches; another species E. macrocarpa has flowers up to 7 inches across. The tallest and most beautiful is the Karri, E. diversicolor

of which trees of nearly 300 ft. with a bole 150 ft. before the first branch are common. Their slender trunks 30 ft. round, are covered with a white mottled bark, so that they " suggest the columns of some mighty cathedral." Except in the region of these Karri the forest is open and park like, with no thick or tall undergrowth—a Savannah woodland.

P. F. F.

Fungi.

Sundaraman, S., Ustilago Crameri *Koern* on Setaria italica *Beauv. Bull. No. 97 of the Agr. Res. Inst. Pusa.* *As. 4.

It has long been known that smuts of various kinds cause great loss in cereal crops and this is an account of the investigation into that of Setaria italica which is grown very largely in South India and more especially in the North Central districts of Cuddapah, Kurnool, Bellary, Anantapur and Guntur.

Mr. Sundaraman finds that the smut spores germinate freely in distilled water even up to 95 per cent. in 12 hours, but failed to germinate when placed in solutions of copper sulphate of 0. 5% for 15 to 30 minutes. The fungus enters the plant in the young seedling stage but does not infect the flowers and the grain is the only part in which it shows itself. Though sometimes the upper spikelets may not show smut while those lower down do, in no case is the reverse found. This of course is because the fungus has entered the plant at the base and crept upwards. It will be seen that in no important detail is Ustilago Crameri different from species common in Europe. But the results are useful as confirmation of the life history of smuts and this kind of work is very necessary.

P. F. F.

Physiology.

Coville, Fredrick V. The Influence of Cold in stimulating the Growth of Plants. *Jour. Ag. Res. 20 : 151-160. 1920.*

For trees and shurbs of cold climates to become dormant low temperatures are unnecessary. But for the resumption of growth after dormancy chilling is required. The stimulating effect of cold is limited to the part of the plant exposed to cold. This effect is produced by the digestion of starch to sugar, due to the weakening of the cell-membrances which separate the enzyme from the stored starch. The accumulation of sugar hastens growth by virtue of the higher osmotic pressure imparted to the cell.

The author discovered, first in his work with blueberries and confirmed by observations on many other plants of the temperate regions, that shoots kept during the winter in a warm greenhouse fail to develop their dormant buds in the spring. A single freezing does not suffice to make the buds develop, but a period of two or three months of exposure to cold is required. This characteristic is a safety device which prevents the premature leafing and flowering of plants during warm periods in early winter and their subsequent death. The necessity of chilling explains why such fruits as apples and pears do not grow successfully in tropical regions. What the gardener speaks of as " resting " is often merely the period of chilling.

The author thinks the extra floral nectaries of plants are safety valves to prevent the rupture of the cell by excessive osmotic pressures. The floral nectaries have had historically, perhaps, the same function, but have been perpetuated by natural selection acting upon their usefulness to the plant in securing insect pollination.

L. A. KENOYER.

Books.

Agnes Arber, Water Plants, a Study of Aquatic Angiosperms *Camb. Univ. Press, 1920. £1-11-6.**

This is a very full and detailed treatise on water plants. Mrs. Arber is well qualified for work of this kind having made many valuable investigations into the structure and evolution of leaves and leaf-like organs; she has also for several years made a special study of water plants. A short time ago she enunciated the principle of the Law of Loss, according to which an organ once lost in the process of evolution cannot be regained, but if the need for such an organ again arises another must be adapted for the purpose (vide p. 179 of this Journal 1 of last year); and the book ends with instances of this principle. The book is divided into four parts; (I) Water Plants as a biological group; (II) The vegetative and reproductive organs of water plants; (III) The physiological conditon of plant life in water; (IV) Water plants considered from the phylogenetic and evolutionary stand points.

In part I is described the life history of the families of water-plants, beginning with the Alismaceae and ending with the marine angiosperms. The last Dr. Arber considers to have been derived from fresh water plants, and not to be the result of the gradual adaptation of sea-shore or other land plants to marine conditions. For the special qualifications necessary to enable a plant to grow in the sea—strong anchoring roots, a power of vegetating when wholly submerged, hydrophilous pollination, and a tolerance of salt water—are found in some at least of the fresh water members of the two families, Hydrocharitaceae and Potamogetonaceae, to which the marine angiosperms belong. It may be recalled that Guppy in the "Naturalist in the Pacific" argued that the floating habit of seeds and fruits which is so characteristic of strand plants was not evolved by adaptation from the coastal vegetation, but was rather the condition necessary to enable inland species to reach the sea at the mouths of rivers and become established on the shore. A very similar argument is advanced by Mrs. Arber to interpret heterophylly. The ribbon-like or divided leaf of the submerged part is regarded as a return to the juvenile state and to be brought about by insufficient nutrition. That is, the submerged form is not an adaptation to the medium, but the property of having such a juvenile form and of returning to it when submerged has been the condition necessary to allow of a species becoming a water-plant.

In regard to Utricularia the author appears not to be acquainted with the work of T. Ekambaram on the bladders of U. flexuosa, which actually suck in the small organisms which touch the trigger hairs. (Agric. Journ. India 1916.)

Three chapters follow on the anatomy of water plants, the aerating and other tissues being dealt with very fully. The author's leaning towards the rigidity of inheritance, if one may call it that, is shown in an observation that the differences which occur in the structure of related plants growing

under the same conditions, must be due to ancestral differences, so that the same sort of idea of the facility to produce aerating tissue being the condition of a submerged life, rather than the result of it, is applicable.

Then follow chapters on the relation of the environment to the vegetative and reproductive parts of water plants. It is impossible to more than mention them here, but like the rest of the book they are full of facts and suggestive ideas.

Part III is devoted to the physiology of water plants and is the shortest of the parts. Stress is laid on the fact that there is really a transpiration current, and that the problem before a submerged plant isnot how to prevent undue loss of water, but how to prevent undue accumulation. For this purpose the leaves are provided with active water-pores. The slimy covering so common in submerged parts is regarded as a by-product of the metabolism, without any particularly useful function.

Part IV, on the phylogeny and evolution of water plants is perhaps the most interesting of the whole book. The first chapter is on dispersal and geographical distribution. The special difficulties in connection with the present day occurrence of species are pointed out, and instances given which seem to support Guppy's theory of widespread primitive forms giving rise to species in different areas; and also Willis' Age and Area theory. The next is on the affinities of water plants. The idea of the Ranalian plexus being the most primitive and connected with the Monocotyledons is accepted, and it is pointed out that the aquatic families are all comparatively primitive, and that among the sympetalae are no absolutaly aquatic familes, nor even a species with hydrophilous pollination. The evidence therefore is that the aquatic families took to this life at a very early stage in the evolutionary history of angiosperms, and that possibly the more highly developed sympetalae are too far specialised for life on land to make successful colonisers of water. The Helobeae, the most important aquatic cohort, possess in the enlarged hypocotyl of the embryo, packed as it is with food, a provision which has probably been one of the chief causes of their success in aquatic life. It is this large and well differentiated cohort which has led to the erroneous conclusion that the Monocotyledons are predominatingly aquatic and to the theory of the aquatic origin of this class. In the last chapters the bearing of the foregoing and other facts on the theory of natural selection is discussed, and evidence adduced to show that the leaves of monocotyledons are to be regarded as equivalent not to the whole leaf of the dicotyledon, but to the petiole and its sheathing base or even to the base alone, and to be in reality a phyllode expanded into a leaf-like lamina. The last pages are devoted to a discussion on the author's principle of the Law of Loss, as explaining these and other peculiarities of aquatic plants.

The whole book is one well worth reading, indeed it might be considered an indispensable part of education in advanced botany. It is well written in smooth easy flowing English, contrasting favourably in this respect with much of modern botanical work, is very well illustrated with numerous original as well as borrowed figures, and is provided with copious bibliography.

P. F. F.

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THE PHYSIOLOGICAL ANATOMY OF THE PLANTS OF THE INDIAN DESERT

BY

T. S. SABNIS, B.A., M.Sc.

(*Continued from p. 107*).

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CHENOPODIACEAE.—(*Contd.*)

Salsola foetida *Del.*—Figs. 287, 289, 290. Leaf suborbicular and fleshy. Stomata depressed. Aqueous tissue subepidermal. Palisade tissue forming a continuous ring. Clustered crystals in subepidermal and central aqueous tissue. Veins peripheral and central. Central veins embedded in a cylinder of stone-cells. Collenchyma below epidermis of the axis. Cortical parenchyma forming an aqueous tissue. Pericycle of small isolated groups of stone-cells. Vascular bundles in the axis embedded in interfascicular wood prosenchyma and forming a hollow cylinder. Pith of thin-walled large cells.

Structure of the Leaf—Epidermal cells in *S. foetida* have outer walls papillose and they are of two sizes, larger ones bearing hairs. Epidermal cells in *H. recurvum* have outer walls convexly arched outwards. Outer walls are not much thickened in any of the members.

The guard-cells are usually placed in the plane of surrounding cells, though in *H. recurvum* they are sometimes distinctly situated below the plane of epidermal cells. Stomata are surrounded by ordinary epidermal cells and the front cavity is closed by outer horns of the guard-cells.

Mesophyll is differentiated into assimilatory and aqueous tissue. The assimilatory tissue in *S. foetida* consists of a continuous ring of palisade cells. Palisade cells in *H. recurvum* form a continuous layer, broken at the angles, in portions of the leaf towards the apex ; but as we proceed examining sections from the apex to the base of the leaf the palisade tissue is seen to disappear also at the middle of the flat

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and arched surfaces of the leaf. In sections of the basal portion, the palisade tissue disappears all along the flat surface. Gaps in the palisade tissue are filled in by palisade-like aqueous cells along the flat surface and by polygonal aqueous cells at the angles and along the middle portion of the arched surface. Some of the polygonal aqueous cells at the angles contain large clustered crystals.

The aqueous tissue consists partly of a continuous layer of subepidermal aqueous cells many of which contain clustered crystals, and chiefly of a centrally placed mass of large aqueous cells which enclose the central veins as well as the smaller ones lying at the periphery of the aqueous tissue. The centrally placed aqueous tissue is bounded by a layer of cubical or tabular cells in those parts where the palisade tissue is present in *S. foetida* and *H. recurvum* respectively. Cells of this layer contain chlorophyll and resemble cells of bundle-sheaths. This layer may assist the assimilatory tissue in carbon assimilation as well as serve to bring into contact the assimilatory and vascular tissue. Some of the peripheral cells of the central aqueous tissue contain clustered crystals in the neighbourhood of the veins.

Oxalate of lime is found in the form of clustered crystals which are found in subepidermal aqueous cells as well as in aqueous cells of the central tissue in the neighbourhood of peripheral veins. Internal glands are not found in the leaf and axis of any members.

The system of veins consists of centrally placed veins, of veins traversing the central aqueous tissue and of peripheral veins situated beneath the sheath-layer which forms a bundle-sheath common to all the veins and which brings into contact the assimilatory and vascular tissues. The central vein in *S. foetida* is embedded in a cylinder of stone-cells, while that in *H. recurvum* is surrounded by a tissue of small thin-walled parenchymatous cells.

Hairy covering on the leaf and axis of *S. foetida* consists of uniseriate trichomes seated on larger epidermal cells. Hairs are composed of a basal portion of a few short cells and of an irregularly curved and pointed terminal portion which consists of longer cells with walls covered with solid papillae (fig. 287). Hairs are not found in both the species of *Haloxylon*. External glands do not occur in any of the members.

Structure of the Axis.—Epidermal cells in *H. recurvum* have outer walls thickened and papillose; those in *H. salicornicum* are tabular and thin-walled and those in *S. foetida* are small polygonal cells with outer walls thickened and granulated. Stomata have the same characters as those on the leaf. Primary cortex is characterised by a sub-epidermal continuous layer of collenchyma in *S. foetida*, by

assimilatory tissue of palisade cells in both the species of *Haloxylon* and by the occurrence of an aqueous tissue in all the members. Collenchyma possesses chlorophyll and may function as an assimilatory tissue in *S. foetida*. Palisade cells form a continuous ring in *H. salicornicum*, while in *H. recurvum* the continuity of the palisade tissue is broken by groups of colourless palisade-like cells with perhaps a water-storing function.

The aqueous tissue is extensive in species of *Haloxylon* and it consists of a sub-epidermal layer of tabular aqueous cells and of a centrally placed tissue of polygonal cells surrounding the central vascular cylinder. The central aqueous tissue is bounded by a layer of cubical cells containing chlorophyll and resembling bundle-sheath cells; and it is traversed by vascular bundles. The aqueous tissue in *S. foetida* is represented by a tissue of polygonal cells below collenchyma and it is not extensive.

In *H. recurvum* (fig. 288) there is cork developed just outside the ring of soft bast and it seems to be of pericyclic origin. It may have been developed to protect the poorly developed central vascular cylinder from desiccation. Pericycle consists of groups of stone-cells. Stone-cell groups in *S. foetida* are very small and isolated. Stone-cell groups in *H. salicornicum* are rhomboidal and present an isobilateral arrangement, the larger ones being developed in the plane most affected by the prevailing wind. In *H. recurvum* it presents a peculiar arrangement. It is composed of long broad and composite strands in the plane of gaps in the palisade tissue and of thin narrow strands or isolated stone-cells in other parts of the pericycle. The occurrence of stronger strands is perhaps necessary in the plane of gaps as the aqueous tissue in this plane is more extensive.

The vascular system is represented by peripheral bundles below the sheath-cells, by bundles traversing the aqueous tissue and by centrally placed bundles in species of *Haloxylon;* in *S. foetida* it consists only of centrally placed bundles. Vascular bundles in the central cylinder are embedded in interfascicular wood prosenchyma of thick-walled cells in a concentric fashion, the largest ones being situated towards the pith. Vessels are small and have simple perforations. Medullary rays are not found.

In addition to a continuous peripheral thin ring of soft bast there are groups of soft bast on the outer side of the bundles, embedded in interfascicular wood prosenchyma.

Pith consists of thick-walled cells in *H. recurvum;* in other members it consists of thin-walled cells.

Oxalate of lime is found in the form of clustered crystals in some of the cells of the aqueous tissue of all the members. Besides

the clustered crystals in the aqueous tissue, there is a continuous layer of rounded thin-walled cells, most of which contain clustered crystals; it is situated beneath the sub-epidermal aqueous tissue in *H. salicornicum*. It may be termed a crystal layer.

General Review.—Epidermal cells have outer walls thin and more or less papillose. Stomata are depressed and guard-cells are situated in the plane of surrounding cells. The assimilatory tissue in the leaf and axis consists of palisade cells. The leaf and axis are characterised by the extensive development of an aqueous tissue, either peripheral, or central or both. The vascular system in the leaf consists of peripheral and central veins; and it is brought into contact with the assimilatory tissue by means of sheath-cells. Hairy coveriug, when present, consists of uniseriate trichomes densely covered with solid papillae. Oxalate of lime occurs in the form of clustered crystals in the leaf and axis.

Sclerenchymatous pericycle is found in all the members. The vascular system in the axis consists of bundles traversing the aqueous tissue as found in species of *Haloxylon* and of a central cylinder as found in all the members. Bundles in the central cylinder are embedded in interfascicular wood prosenchyma in a concentric fashion. Vessels are small and have simple perforations. Medullary rays are not found in any of the members.

POLYGONACEAE.

Calligonum polygonoides *L.*—Figs. 291, 292, Woody. Mesophyll isobilateral with a middle layer of cells with tanniniferous contents. Palisade-like cells with tanniniferous contents in the palisade tissue. Clothing hairs in the form of uniseriate trichomes. External glands club-shaped. Epidermal cells of the axis with outer walls very greatly thickened. Subepidermal groups of sclerenchyma present. Clustered crystals in the primary cortex. Pericycle of small groups of stone-cells. Wood composite. Interfascicular wood prosenchyma extensive. Meduallary rays 1-2 seriate and numerous. Pith of thick-walled cells.

Polygonum plebejum *Br.*—Fig. 293. Woody. Large water-storing cells intercalated amongst epidermal cells. Mesophyll of palisade tissue on the upper side and of arm-palisade tissue on the lower. Clustered crystal in the mesophyll. Bundle-sheath cells with tanniniferous contents.

Epidermal cells of the axis with outer walls granulated. Collenchyma groups subspidermal. Wood composed of xylem bundles. Pith of thin-walled cells.

Structure of the Leaf.—Epidermal cells are polygonal with outer walls thickened and papillose on both the sides in *C. polygonoides* and on the upper only in *P. plebejum*. Epidermal cells on the upper side in the latter are tabular with outer walls thickened and flat. Large water-storing cells are intercalated amongst ordinary epidermal cells in *P. plebejum*. Lateral walls are thin and undulated.

Stomata are surrounded by ordinary epidermal cells and are equally numerous on both the surfaces. Guard-cells are in the plane of surrounding cells and the front cavity is placed in a depression formed either by outer thickened epidermal walls or by the papillæ.

Mesophyll is isobilateral in *C. polygonoides*, while in *P. plebejum* it consists of palisade tissue on the upper side and of arm-palisade on the lower. There is a tissue of polygonal cells with tanniniferous contents in the middle of the mesophyll in *C. polygonoides*.

Internal secretory organs are represented in *C. polygonoides* by polygonal cells in the middle of the mesophyll and by palisade-like cells, in the palisade tissue, with tanninifarous contents. Sheath-cells in *P. plebejum* hold tanniniferous contents. Oxalate of lime occurs in the form of clustered crystals in the mesophyll of *P. plebejum*.

Veins are embedded and are enclosed in bundle-sheaths. Sheath-cells in *P. plebejum* hold tanniniferous contents.

Hairy covering, in *C. polygonoides*, consists of uniseriate trichomes which are composed of a basal cell and of a terminal cell with verrucose walls and more or less adpressed. External glands in *C. polygonoides* are club-shaped and consist of a biseriate short stalk and of a head irregularly divided.

Structure of the Axis.—The epidermis consists of small polygonal cells with outer walls thickened and papillose, thickening being considerable in *C. polygonoides*. Outer walls are granulated in *P. plebejum*. Lateral walls are thin and undulated. Some of the epidermal cells in *C. polygonoides* hold tanniniferous contents. The primary cortex is characterised by an assimilatory tissue of palisade cells. The mechanical tissue is represented by sub-epidermal strands of collenchyma and of stone-cells in the ribs of *P. plebejum* and *C. polygonoides* respectively. Along almost one-third of the circumference of the axis, cork is developed below epidermis. This suggests that the axis is greatly inclined and that cork is developed on the upper side which is exposed to the sun. Endodermis is differentiated and is characterised by tanniniferous contents in the species of both the genera. The pericycle is composed of small groups of stone-cells (figs. 292, 293). Stone-cell groups in *C. polygonoides* are radially much elongated. Cells interposed between stone-cell groups are

parenchymatous and hold tanniniferous contents in both the members.

Wood forms of a composite hollow cylinder in *C. polygonoides*, while in *P. plebejum* it consists of xylem bundles connected by strands of interfascicular wood prosenchyma. Vessels in *C. polygonoides* are small and few; they are uniformly distributed in extensive interfascicular wood prosenchyma formed of small cells with thick walls and with small lumina. Medullary rays are present only in *C. polygonoides* and are 1-2 seriate. Vessels in the xylem bundles of *P. plebejum* are many and large and the connecting strands of interfascicular wood prosenchyma are formed of cells with thin walls and with large lumina. Wood parenchyma is little developed.

Pith consists of thin-walled and thick-walled cells in *P. plebejum* and *C. polygonoides* respectively.

Oxalate of lime is found in the form of clustered crystals in the assimilatory tissue and in cortical parenchyma near the pericycle. Secretory cells with tanniniferous contents occur in the epidermis, cortical parenchyma and pith in species of both the genera. Tannin is also found in the medullary ray-cells of *C. polygonoides*.

The mechanical tissue consists of sub-epidermal strands and of pericyclic stone-cell groups. Sub-epidermal strands are collenchymatous in *P. plebejum*, while those in *C. polygonoides* are formed of stone-cells. Sub-epidermal strands and the pericyclic stone cell groups together form a system of I-girders, the webs being formed by the assimilatory tissue. The occurrence of the mechanical tissue in the form of I-girders in the periphery of the axis forms a suitable strengthening tissue in the axis which is exposed to the strong winds of the desert.

ARISTOLOCHIACEAE.

Aristolochia bracteata *Retz.*—Epidermis of tabular cells. Stomata found on both the surfaces and accompanied by ordinary cells. Mesophyll bifacial. Clothing hairs uniseriate and bracket-shaped. Veins embedded and with bundle-sheaths.

Structure of the leaf.—The epidermis consists of tabular cells with outer walls thickened and convexly arched outwards. Lateral walls are thin and straight. Stomata are more numerous on the lower surface and are accompanied by ordinary epidermal cells. Guard-cells are in the plane of surrounding cells and the front cavity is placed in a depression formed by outer thickened epidermal walls.

Hair convering consists of a few clothing hairs which are uniseriate and bracket-shaped. They are composed of a unicellular dome-shaped pedestal seated on epidermal cells, of a neck and of a

terminal cell bent like a hook. The tip of the hair is sharp and solid. External glands are not found.

Mesophyll is bifacial. Internal secretory organs and oxalate of lime are not found. Veins are embedded and are provided with green bundle-sheaths.

EUPHORBIACEAE.

Euphorbia granulata *Forsk.*—Fig. 294. Epidermal cells of the leaf with outer walls greatly papillose. Internal glands absent in the leaf. Internal secretory cells in the axis with tanniniferous contents. Veins provided with bundle-sheaths. Clothing hairs uniseriate trichomes with muriculate walls. Epidermis of the axis one-layered. Pericycle of isolated bast fibres. Vessels numerous. Interfascicular wood prosenchyma not extensive.

Phyllanthus niruri *L.*—Fig. 295. Epidermal cells of the leaf with outer walls a little papillose. Internal secretory cells with tanniniferous contents in the spongy tissue. Numerous solitary crystals in the palisade tissue. Veins without bundle-sheaths. Clothing hairs thick-walled and unicellular or septate. Epidermis of the axis two-layered. Collenchyma in the ribs of the axis. Pericycle forming a loose ring of groups of bast fibres. Vessels few. Interfascicular wood prosenchyma extensive.

Structure of the leaf.—Epidermal cells have outer walls thickened and papillose, papillae being large and conspicuous in *E. granulata* (fig. 294). Inner walls are also a little thickened. Lateral walls are thin and straight. Stomata are more numerous on the lower surface and are accompanied by ordinary epidermal cells. Guard-cells are in the plane of surrounding cells and the front cavity is placed in a depression formed by papillae.

The mesophyll is bifacial. Internal secretory organs are represented by numerous large polygonal cells with tanniniferous contents in the spongy tissue in the leaf of *P. Niruri*. In the axis of *E. granulata* there are numerous thick-walled elliptical cells with tanniniferous contents, interposed between the groups of bast fibres. Internal secretory cells are absent in the leaf and axis of *E. granulata* and *P. Niruri* respectively. Oxlate of lime is found in the form of numerous solitary crystals in the palisade tissues of the leaf in *P. Niruri*.

Veins are embedded and are enclosed in distinct green bundle-sheaths in *E. granulata*. Bundle-sheaths are not found in *P. Niruri*.

Structure of the axis.—The epidermis in *P. Niruri* is two-layered; cells of the outer layer have outer walls greatly thickened and granulated. Epidermis in *E. granulata* is single layered; epider-

mal cells have outer walls thickened, granulated and convexely arched outwards. Lateral walls are thin and straight. Primary cortex is composed of chlorenchyma. Collenchyma is developed in the ribs of *P. Niruri*.

Pericycle forms a loose ring of groups of bast fibres in *P. Niruri*, while *E. granulata* it is represented by isolated bast fibres. Wood forms a composite hollow cylinder with vessels distributed uniformly in incomplete rows in interfascicular wood prosenchyma. Vessels are more numerous in *E. granulata*. Medullery rays are uniseriate and numerous.

Pith consists of very thin-walled cells.

LILIACEAE.

Asparagus racemosus *Willd* **Var. javanica** *Bak.*—Epidermal cells with dark-brown granules. Cork subepidermal. Pericycle forming a composite ring of stone-cells. Vascular bundles scattered in a concentric fashion in the ground tissue. Ground tissue formed of cells with walls thin and lignified.

Structure of the Axis.—The epidermis consists of tabular cells. Epidermal cells have outer walls a little thickened and are filled with dark-brown granules. Lateral walls are thin and straight. Cork is subepidermal and is formed of thin-walled cork cells. The pericycle forms a composite ring of stone-cells outermost layer of which consists of a little larger stone-cells with larger lumina. Vascular system consists of numerous bundles which are scattered in the ground tissue and are roughly arranged in rings. Bundles get smaller towards the periphery. The ground tissue is formed of cells with walls thin and lignified. The central portion of the ground tissue enclosed by the innermost ring of bundles consists of very thin-walled cells.

COMMELINACEAE.

Commelina albescens *Hassk.*—Figs. 296, 297. Epidermal cells of the leaf tabular, thin-walled and with outer walls flat. Stomata on both the surfaces and accompanied by subsidiary cells. Mesophyll of palisade tissue on the upper side and of arm-palisade tissue on the lower. Internal glands in the form of cells with tanniniferous contents. Bundles of acicular raphides in lower epidermal cells. Clothing hairs on the leaf in the form of uniseriate bracket-shaped trichomes. Pericycle forming a composite ring of stone-cells. Collenchyma subepidermal. Assimilatory tissue lacunar Vascular bundles apposed to the stone-tissue of pericycle. Numerous isolated secretory receptacles surrounded by parenchyma in the ground tissue.

Structure of the Leaf.—The epidermis consists of thin-walled tabular cells which are larger on the upper surface. Outer walls are flat and lateral walls are thin and straight.

Stomata are more numerous on the lower surface and are accompanied by subsidiary cells. Guard-cells are in the plane of subsidiary cells which are elevated. The front cavity is on a level with the surface. Stomata on the axis have the same characters as of those on the leaf.

The mesophyll is composed of palisade tissue on the upper side and of loose arm-palisade tissue on the lower with an extensive system of intercellular spaces. Internal glands occur in the form of a few cells with tanniniferous contents in the mesophyll. Oxalate of lime is found in the form of bundles of acicular raphides in lower epidermal cells of the leaf; it does not occur in the axis.

Leaves are many-ribbed. Veins of the ribs are vertically transcurrent below by sclerenchyma. Smaller veins are embedded. Veins are enclosed in green bundle-sheaths.

Hairy covering consists of a few clothing hairs. They are uniseriate and bracket-shaped and are composed of a unicellular dome-shaped pedestal seated on epidermal cells, a long neck-cell and of a terminal cell bent like a hook, the tip being sharp and solid. Hairs are absent on the axis. External glands do not occur on the leaf and axis.

Structure of the Axis.—The epidermis consists of tabular cells with outer walls thickened and convexly-arched outwards. Lateral walls are thin and straight. The cortex is composed on its outer side of subepidermal collenchyma and on its inner side of assimilatory tissue of arm-palisade cells arranged in a lacunar manner. The pericycle forms a composite ring of stone-cells. The vascular system is composed of scattered vascular bundles usually apposed to the pericyclic stone-cell ring and protected on their inner side by thin arcs of stone-cells.

The ground tissue is formed of large thin-walled parenchymatous cells filled with starch grains. It is characterised by the occurrence of numerous isolated secretory receptacles surrounded by small-celled parenchyma.

CYPERACEAE.

Cypeurs niveus *Retz.*—Figs. 298, 299. Margins bluntly pointed and supported by stereome bundles. Extensive articulation tissue on the upper side of the leaf. Stomata on the lower side only. Front cavity on a level with the surface. Veins embedded and more or less in a single layer, large ones alternating with the smaller. All

veins apposed to the stereome girders except a few very small ones. A few larger veins vertically transcurrent above and below by stereome. Bundle-sheaths, when present, internal. Mechanical tissue in the leaf in the form of isolated subepidermal girders below the veins, and of a few isolated girders on the upper side placed at regular intervals. T. S. of the axis triangular. Assimilatory tissue in the axis forming arcs or girders of palisade cells round the peripheral bundles. Mechanical tissue in the axis in the form of isolated sub-epidermal girders, larger ones alternating with the smaller. Ground tissue not differentiated in the centre into pith.

Cyperus arenarius *Retz.*—Margins bluntly pointed without any supporting stereome bundles. Stomata only on the lower surface and with the front cavity depressed. Obconical groups of elongated cells occurring below the epidermis even in the absence of stomata. Veins embedded. Smaller veins near the lower epidermis. Bundle-sheaths, when present in leaf or axis, internal. Mechanical tissue in the form of isolated sub-epidermal girders below smaller veins. T. S. of the axis circular. Assimilatory tissue in the axis forming arcs or girders of palisade cells round peripheral bundles. Mechanical tissue in the axis forming numerous isolated girders, larger ones alternating with the smaller. Ground tissue not differentiated in the centre into pith.

Cyperus conglomeratus *Rottb.*—Figs. 300, 301, 302. Margins bluntly pointed and supported by stereome bundles. Extensive articulation tissue on the upper side. Stomata only on the lower surface. Front cavity depressed. Obconical groups of elongated cells occurring below the epidermis even in the absence of stomata. Bundle-sheaths, when present, internal. Veins embedded and arranged in an alternating fashion in two rows. Smaller veins nearer the lower epidermis. Mechanical tissue in the leaf in the form of isolated sub-epidermal girders below all smaller veins and of a single long sub-epidermal girder on the upper surface near the margin. T. S. of the axis circular. Assimilatory tissue, in the axis forming arcs or girders of palisade cells round the peripheral vascular bundles. Mechanical tissue of sub-epidermal girders, alternating with the peripheral bundles and apposed to the girders. A few vessels enclosed in a thick ring of stereome in the ground tissue. Ground tissue differentiated in the centre into pith.

Cyperus rotundus *L.*—Figs. 303, 304, 305, 306, 307. Margins rounded and without supporting stereome bundles. Upper epidermis modified into articulation tissue. All veins embedded. Larger veins nearer the lower epidermis and the smaller ones in the middle of the

mesophyll. Bundle-sheaths, when present, internal. Isolated sub-epidermal girders below all larger veins and those on the upper side developed alternately above the larger veins. T. S. of the axis triangular. Of sub-epidermal girders in the axis, larger ones alternating with smaller ones. Assimilatory tissue forming arcs or girders of palisade cells round the peripheral bundles. Ground tissue differentiated in the centre into pith.

Fimbristylis tenera *Boeck.*—Fig. 308. Margins angular, the two angles supported by stereome bundles. Upper epidermal cells forming articulation tissue. Stomata only on the lower surface. Front cavity elevated above the surface. Veins embedded and arranged in a single row in the middle. Bundle-sheaths when present internal. Mechanical tissue in the leaf in the form of isolated sub-epidermal girders on the upper surface, at the angles of the margin and on the lower side of the mid-rib. T. S. of the axis circular and grooved. Assimilatory tissue in form of arcs or girders of palisade cells round the peripheral bundles. Vascular bundles below the furrows larger and longer and without protecting stereome girders. Mechanical tissue in the axis in the form of isolated sub-epidermal girders in the ribs. Ground tissue not differentiated in the centre into pith.

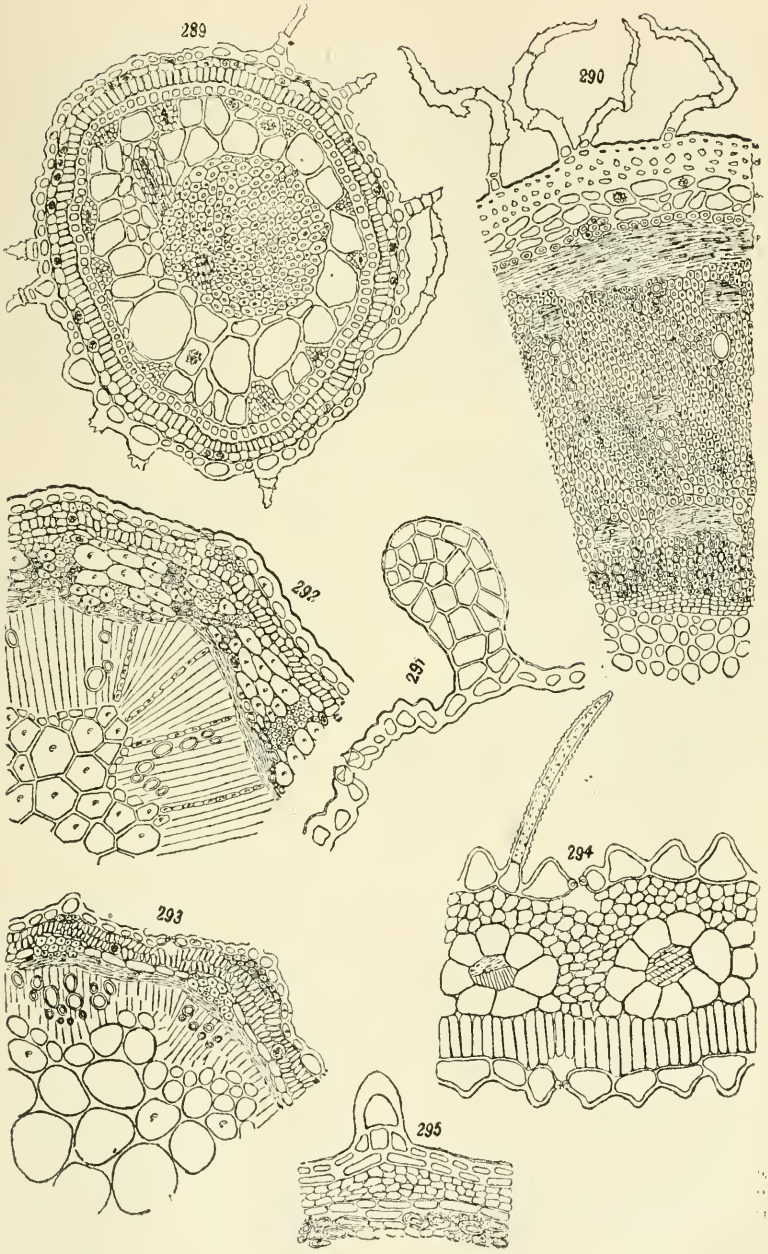
Scirpus quinquefarius *Ham. L.*—Figs. 309, 310. Leafless. T. S. of the axis circular. Front cavity on a level with the surface. Assimilatory tissue of palisade cells below and between stereome bundles. Smaller vascular bundles peripheral and placed in the assimilatory tissue; larger ones placed in the ground tissue. Bundles enclosed in an outer ring of polygonal colourless cells and an inner ring of stone-cells. Mechanical tissue in the form of isolated sub-epidermal stereome girders. Ground tissue characterised by a system of very large air spaces.

(*To be Continued*).

Plate XXIX

289-290. *Salsola foetida.*
289. T. S. of the leaf.
Oc. 2 Com.; Ob. 3 mm. Ap.
290. T. S. of the axis.
Oc. 2 Com.; Ob. 3 mm. Ap.
291-292. *Calligonum polygonoides.*
291. T. S. of the leaf showing a stoma and a glandular hair.
Oc. 6 Com.; Ob. 3 mm. Ap.
292. T. S. of the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.
293. *Polygonum plebejum.*
Oc. 4 Com.; Ob. 8 mm. Ap.
294. *Euphorbia granulata.*
T. S. of the leaf.
Oc. 4 Com.; Ob. 3 mm. Ap.
295. *Phyllanthus Niruri.*
T. S. of the axis as far as the pericycle.
Oc. 6 Com.; Ob. 8 mm. Ay.

N.B.—To get the original dimensions multiply by 1-7.

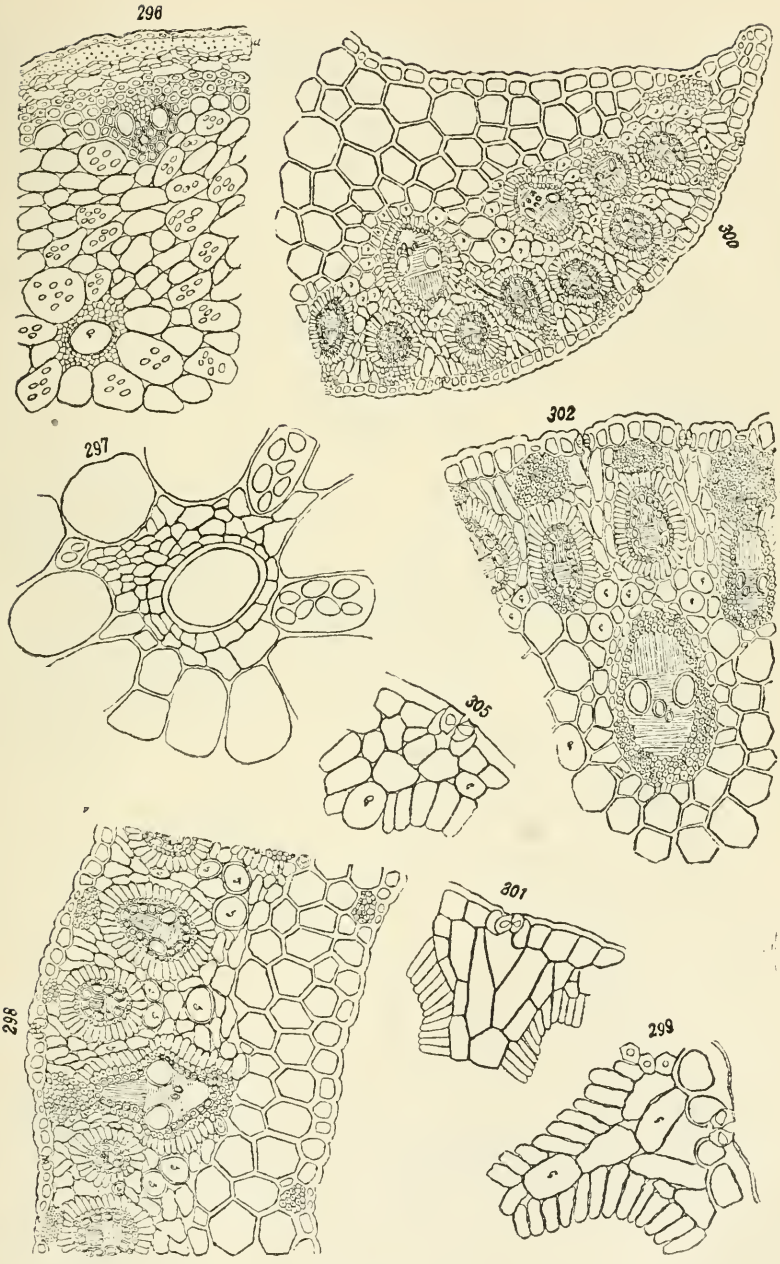


T. S. Sabnis del. PLATE XXIX.

Plate XXX

296-297. *Commelina albescens.*
296. T. S. of the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.
297. Internal gland in the axis.
Oc. 4 Com.; Ob. 3 mm. Ap.
298-299. *Cyperus niveus.*
298. T. S. of the leaf.
Oc. 6 Com.; Ob. 8 mm. Ap.
299. Stoma on the leaf.
Oc. 6 Com.; Ob. 3 mm. Ap.
300-302. *Cyperus conglomeratus*
300. T. S. of the leaf.
Oc. 4 Com.; Ob. 3 mm. Ap.
301. Stoma on the leaf.
Oc. 4 Com.; Ob. 3 mm. Ap.
302. T. S. of the axis.
Oc. 6 Com.; Ob. 8 mm. Ap.
305. *Cyperus rotundus.*
Stoma on the leaf.
Oc. 8 Com.; Ob. 3 mm. Ap.

N.B.—To get the original dimensions multiply by 1·7.



T. S. Sabnis del. PLATE XXX.

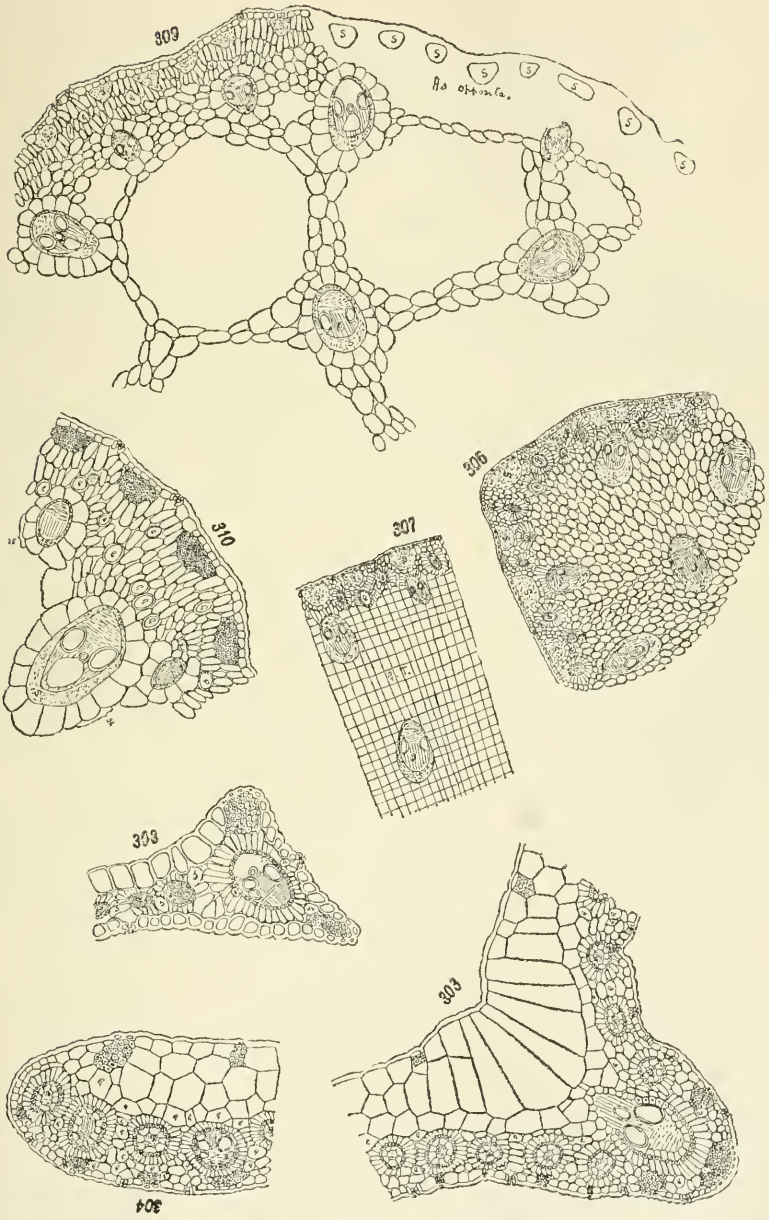
Plate XXXI

303-307. *Cyperus rotundus.*
303. T. S. of the leaf at the mid-rib.
Oc. 6 Com.; Ob. 8 mm. Ap.
304. T. S. of the leaf near the margin.
Oc. 2 Com.; Ob. 3 mm. Ap.
306. T. S. of the axis at the angle.
Oc. 2 Com.; Ob. 8 mm. Ap.
307. T. S. of the axis between the angles.
Oc. 2 Com.; Ob. 8 mm. Ap.

308. *Fimbristylis tenera.*
T. S. of the leaf near the margin.
Oc. 2 Com.; Ob. 3 mm. Ap.

309-310. *Scirpus quinquefarius.*
309. T. S. of the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.
310. T. S. of the axis.
Oc. 6 Com.; Ob. 8 mm. Ap.

N.B.—To get the original dimensions multiply by 1·7



T. S. Sabnis del. PLATE XXXI.

ON A COLLECTION OF MOSSES FROM THE KANARA DISTRICT.

BY

H. N. Dixon, M.A., F.L.S.,

Northampton, England.

I have in my herbarium numerous unpublished species of Mosses from various parts of India, including the types of a considerable number of new species, mostly from the Madura District, S. India, proposed by Mons. Cardot, and received from him before the war. Various reasons prevent the publication of these at the present time, not least the high cost of printing. A new Moss Flora of India is greatly needed, and if in the course of the next few years this should be possible, it may be best to include the publication of these new species in such a work.

The present collection, however, was made in a somewhat restricted area, and it seems desirable to treat it independently, being made in a little worked district, and with some rather special features of geographical and climatic interest. It was made by Mr. L. J. Sedgwick, F.L.S., on a trip with some friends to the Gairsoppa Falls, *via* Kanvar and the Devimane Ghat, all in N. Kanara, in October 1919, and the country further inland South and West of Dharwar during three preceding years.

Mr. Sedgwick has collected mosses in several parts of the Bombay Presidency, in or near the Western Ghats; some of the results have been already published (cf. Journ. of Bot. 47, p. 157; 48, p. 297; 49, p. 137; 50, p. 145), while others await publication.

The rapid diminution in the rainfall as one proceeds eastwards from the crest of the Ghats is very striking, and the character of the moss-flora is naturally very directly affected by it. Thus at Castle Rock, about 15. 5° N. lat, and 74. 5° E. long., the rainfall is about 250 in., not much less than its maximum in the Ghats (at Mahableshwar it reaches 276 in.); at Anmod, which is close to Castle Rock, it has already fallen to probably about 150 in.; while at and round about Dharwar, less than 50 miles inland, it is about 30-40 in., annually.

It will give some idea of the collecting ground, and at the same time will avoid much repetition of details in the list of mosses if I reproduce here some notes sent me by Mr. Sedgwick as to several of the localities where gatherings were made.

Anmod	... Close to Castle Rock, but rainfall less; probably not more than 150 in.
Dharwar	... Long. 75 and due E. of Castle Rock ; alt. 2400 ft.; rainfall 32 in.
Nigadi	... A few miles west of Dharwar.
Tadas	... About 30 miles S.S.W. of Dharwar ; altitude similar ; rainfall about the same.
Konankeri	... About ten miles south of Tadas ; alt. about 2000 ft.; rainfall about 35 in.
Shiggaon	... About 40 miles S. S. E. of Dharwar ; rainfall below 30 in. The few mosses gathered here were from tree boles, &c, in a spice garden, *i.e.* an artificially shady and moist spot in the very dry area.
Siddhapur	... Alt. 1600 ft.; rainfall 120 in.
Jog.	... Alt. 1400 ft. ; rainfall 200 in. at least, possibly very much more, supplemented by heavy nightly mists from the Gairsoppa falls.
Sampkhand	... Rainfall 200 in.
Karwar	... Near coast ; sea-level. Rainfall 120 in.

It is not to be expected, however, that the diverse phytogeographical conditions of the above localities will be very clearly reflected in the present collection, a small one, consisting of only 120 numbers ; any such conclusions could only be come to by means of comparative tables based on a fairly thorough exploration of the different localities.

To save space I have not included detailed records of several of the more common S. Indian species, each represented by several numbers ; viz. *Octoblepharum albidum* (4) ; *Macromitrium sulcatum* (4) ; *Bryum coronatum* (4) ; *Bryum Wightii* (3) ; *Pogonatum aloides* (1) ; *Diaphanodon procumbens* (5) ; *Ectropolhecium cyperoides* (4).

The types of the new species are in my herbarium.

ARCHIDIACEAE.

Archidium birmannicum Mitt. MS. in Herb., sp. nov. (fig. 1).

Caespites densi, olivaceo-virides, *A. alternifolium* referentes ; caules 1-2 cm. alti, tenelli, flexuosi, plerumque simplices, saepe flagelliformes, microphylli ; caulis fertilis apud inflorescentiam innovationes plures emittens. Folia caulina *circa 1 mm. longa*, hic late, illic anguste lanceolata, *latiuscule* acuminata, integra vel subintegra ; costa *sat valida*, apud basin circa 50 μ *1* lata, flava, *percurrens vel prope apicem desinens*. Areolatio foliorum caulinorum *sat laxa*, cellulis *elongatis*, anguste rhomboideo-hexagonis, sublinearibus, 6-8 μ latis,

teneris, instructa; cellulae basilares multo laxiores; foliorum innol vationum breviores, firmiores. Fructus *aggregatus*, thecis 3-4 vepluribus simul emissis; bracteae perichaetiales plures, erectae, quam folia longiores, latiores, concavae, ceterum foliis caulinis similes. Theca (vix matura) 3 mm. longa, sphaerica, in vaginula 1 mm. longa sessilis. Cetera ignota.

Hab. Rocks on hill-side, Karwar (6383) Sedgwick. c. fr. Rock, on open hill, Jog (6477) Sedgwick, apparently sterile. Moulmein. Burma, Rev. C. S. P. Parish (698) at. Herb. Mitten.

Differs from *A. alternifolium* in the longer. narrower leaves, with elongate, more delicate areolation, the aggregate setae, etc.

A. indicum Hampe and C. M. differs in the smaller size very narrow, elongate finely subulate leaves, and thinner nerve.

I have found only two fruiting stems, the leaves of which do not differ widely from those of the sterile stems. I have not dissected an inflorescence; it is probably paroicous. The nerve is not excurrent, even in the perichaetial leaves.

The Burmese plant is sterile, and I have therefore made the fruiting plant the type.

A. indicum appears at Kew as "*A. indicum* Hpe...Pegu; Yomah; Kurz, No. 2889," Paris has it—"*A. indicum* C.M. in Fl. 1888, No, 1," The true citation appears to be :—

A. Indicum Hampe and C.M. in Fl. 1888, p. 8.

A further Indian species sent me by Mr, Sedgwick, gathered by Mr. R. B. Kinnear at Chikalda, C.P., is at present undescribed.

DICRANACEAE

Leucoloma Renauldii Broth. Stem of tree, Jog. (6468).

Sedgwick's plant agrees quite well with the description of this very distinct species.

Brotherus (Musci, 1, 324) places *L, Renauldii* in the § Vittata (Sub-gen. Taeniodictyon Ren.); but Renauld (Essai sur les Leucoloma, p. 42) puts it in Sub-gen. Syncratodictyon, (§ Transmutantia) where no doubt it belongs from the character of the cells ("basin versus sensim longioribus"), and its relationship to e.g. *L. amoenevirens* Mitt. It appears to be somewhat intermediate between that and *L. strictifolium* described below, but is very distinct in the unusually narrow leaves and nearly smooth cells.

Leucoloma Walkeri Broth. On stem of *Calophyllum*, Sampkhand (6443).

Leucoloma strictifolium Dixon sp. nov. (fig. 2).

§ Transmutantia. Caespites *extensi*, dense intertexti, saturate virides, caules 1.5—2cm. alti, *strictiusculi*, sat robusti. Folia erecto-

patentia, sicca *erecta*, *stricta*, *nec flexuosa nec falcata*, 3—3.5 mm, longa, e basi oblongo-lanceolata, .3—.4mm. lata, *e basi fere sensim angustata*, in subulam *praelongam*, *subintegram*, *setaceam*, *strictam* excurrentia,

Cellulae superiores minutissimae; subquadratae, opacae; internae chlorophyllosae, *laeves vel sublaeves*, basin versus *sensim* in basilares ubique breviter oblongas, pellucidas, quarum series paucae marginales aliquando altius quam juxtacostales adscendunt, transmutatae; alares magnae, vesiculares, internae pulchre aurantiacae, externae in seriebus 1—2 plerumque hyalinae. Limbus marginalis hyalinus *pernotatus latus*, inferne seriebus plus minusve 6—8 instructus, ad apicem minutissime denticulatam productus. Costa basin versus 35—45 mm. lata, superne hyalina.

Seta 1 cm. fere longa, flexuosa; theca subsymmetrica, subcylindrica, operculo oblique rostrato.

Hab. On *Calophyllum*, Sampkhand (6444).

Nearest probably to *L. Walkeri* Broth., which is a smaller, more delicate plant with leaves somewhat flexuose when dry, and remarkably narrow below.

The cells are smooth, or obscurely papillose only, in mid-leaf; the leaves entire or very minutely denticulate at apex. The habit is very distinct.

FISSIDENTACEAE.

§ Bryoidium.

Fissidens Zollingeri Mont. On rotten earth inside a tree, Mirjan; alt. 300 ft.; rainfall 150 in. (6414).

§ Semilimbidium.

Fissidens Walkeri *Broth.* Earth-bank of stream, Anmod (3265). Stone in stream, Sampkhand (6436) (6449) Earth-bank in evergreen, Sirsi; rainfall above 100 in.; alt. 1800 ft. (6459).

var. elimbatus (Broth.) Dixon comb. nov. (*Fiss. elimbatus* Broth. in Records of Bot. Survey of India I 316 (1899). Tinai Ghat, Castle Rock, N. Kanara (3262).

I have not seen authentic specimens of the two plants described by Brotherus as independent species; but I do not think there can be any doubt, from the descriptions, of the identity of these plants.

Brotherus separates *F. elimbatus* from *F. Walkeri* solely on the following ground :—

"Species praecedenti (*F. Walkeri*) simillima, sed laminis omnibus elimbatis dignoscenda."

F. Walkeri has a weak border on the vaginant lamina, reaching only halfway up the lamina. No 3262 differs only in having no trace

of the border, and I think its proper place is as a var. of *F. Walkeri*, in spite of the objection that it is thus necessarily placed in the § Semilimbidium, characterized by the presence of a border on the vaginant lamina. The objection is a practical, not a scientific one, however; for there is no doubt that the presence of a weak border, or the entire absence of a border on the vaginant lamina, may at times be a character of scarcely any taxonomic value. One example, a Fissidens sent me recently from Fiji by Mr. W. Greenwood, manifested no trace whatever of border, and I determined it as a new species of Crenularia. Subsequently further specimens of what was obviously the same moss showed traces of a faint border to the vag. lamina here and there; and later, fertile specimens showed a distinct border, (while leaves on the sterile stems of the same gathering often showed none at all); and the plant was recognizable as an already described species of Semilimbidium. In this connection it may be noticed that *F. Zippelianus* Bry. jav. (a Javan species with a somewhat wide distribution both East and West) while normally without border and placed by C. Mueller and Brotherus in Crispidium, is figured in the Bry. jav. showing a border on the vag. lamina; which appears to bring it into very close relationship with *F. Walkeri*.

Fissidens subfirmus Dixon sp. nov. (fig. 3).

Sordide viridis; caespites densos instruens. Caules circa 1 cm, alti, vel paullo ultra, saepe ramulosi; folia *confertissima*, subaequalia, frondem regularem densam circa 2 mm. latam instruentia, sicca *eniter deplanata haud crispata*, circa 1 mm. longa, oblongo-lingulata, *acuta nec acuminata*, *aliquando tantum subacuta*, superne cellulis marginalibus prominentibus minute denticulata. Lamina vaginans circa $\frac{1}{2}$ longitudinis folii, *limbo superne angustissimo infra latiusculo* plus minusve distincte circumdata; lamina dorsalis ad folii insertionem producta, ibique rotundata; costa *sat valida*, *tricta*, bene definita, flava, percurrens. Cellulae *majusculae*, 8-13 μ latae, hexagonae, *parietibus firmis*, *crassiusculis*, *subpellucidae*. Theca in pedunculo perbrevi (2-3mm.) *crassiusculo*, indistincte ruguloso, subcurvato, erecta vel. leniter inclinata, symmetrica, ovalis, *subpachydermata*, *parva*, *sicca subore vix coustricta*. Operculum haud visum.

Hab. Anmod (3266), (5375).

A marked species with rather large, pellucid cells, and vag. lamina distinctly bordered (the border is most distinct in the perichaetial leaves and upper stem leaves, and may be almost or quite wanting in the lower leaves); in the short subrugulose seta, and minute rather thick-walled capsule.

F. subobscurus Par. (*F. obscurus* Mitt. in Journ. Linn. Soc., Bot. Vol. III. Suppl. p. 139, *nec F. obscurus* Mitt. op. cit. p. 138) is

very near, but differs in more distant, longer and narrower leaves, more acute and without any border.

F. firmus Mitt. is still nearer, but is a taller plant, with more acute leaves, very stout nerve, and very strong border on the vaginant lamina. No fruit is present on Mitten's type. It is possible that the present plant may ultimately have to be united with it. It appears to have been gathered in a more or less aquatic situation.

Fissidens karwarensis. Dixon sp. nov. (fig. 4).

E minoribus generis caulis 3-4 mm. altus, plurijugus, frondem angustam, atro-viridem sistens. Folia inferiora parva, superiora multo majora, *laxiuscule* disposita, *deplanata*, sicca fortiter falcato-incurva, fragilia, oblongo-lanceolata, acuta; lamina vaginans ad dimidiam partem folii producta vel paullo ultra; *ea foliorum inferiorum plerumque immarginata, foliorum superiorum atque praecipue floralium fortiter limbata, limbo aliquando perlato*; lamina apicalis et dorsalis elimbata, minutissime crenulata, lamina dorsalis ad folii basin producta ibique plerumque rotundata; costa angusta, pellucida, subpercurrens, vel in apiculum egrediens. Areolatio *perdensa*, e cellulis *minutissimis papillosis* instructa. Seta *brevis*, 2-4 mm., tenella; theca minuta, anguste elliptica, collo defluente, erecta vel leniter inclinata, sub ore constricta operculo conico-rostrato, acuto.

Dioicus videtur; flores. haud visi.

Hab. Stones, Karwar (6368). Bole of coconut palm in irrigated spice garden, Shiggaon (3485).

Near to *F. ceylonensis* Mitt, but that has still more opaque and obscure cells, narrower leaves, and dorsal lamina narrowed to base. *F. Treubii* Fleisch, also is very similar, but the leaves there are much longer, narrower and closer together.

The border is rather remarkable, being entirely absent from most of the leaves, but in the uppermost leaves of the fertile stems well marked and even unusually broad. Even there however it is highly variable and may be wanting.

§ Aloma.

Fissidens immutatus Dixon sp. nov. (fig. 5).

Caules aggregati, vix caespitosi, *rufescentes*, simplices vel parce ramosi, vix 1 cm. alti, multijugi, fusco-rubri. Folia flavo-virides, *laxe disposita*, complanata, patentia, *sicca haud mutata vel minime deplanata*, frondem pulchram *subnitidam* sistentia, rigida, oblonga, breviter acuminata vel acuta, subintegra, immarginata; lamina vag. vix ad medium folium attingens, *apice plerumque obtuso*; lamina dorsalis ad folii basin producta, ibique crenulata, rotundata; costa valida, pellucida, subflexuosa, in summo apice evanida. Areolatio perpellucida,

cellulis hexagonis; 12-16 μ latis, laevibus parietibus incrassatis, pellucidis, instructa. Cetera ignota. Hab. Earth-bank, Karwar (6380); earth-bank inevergreen, Sirsi; above 100 in. rainfall, alt, 1800 ft.

A very pretty species with the frondiform stems quite unaltered in drying, the leaves glossy, rigid, subcartilaginous, pale. In habit it comes near *F. firmus* Mitt, but that has the vaginant lamina strongly bordered.

§ Crispidium.

Fissidens Zippelianus Daz. and Molk.

Stones, Karwar (6376); stones in stream in dense evergreen, Guddahalli Hill, Karwar (6399): stones in stream, Sampkhand (6448).

Fissidens macrosporus Dixon sp. nov. (Fig 6).

Stirps parva, corticola, gregaria, arborum ramulis crescens, uberrime fructificans. Caulis simplex, rigidus, laevis (circa 5 mm. longus); saturate viridis. Folia sicca *rigide falcata*, madida complanata, frondem brevem subflabelatam instruentia, pro magnitudine plantae majuscula, 1-1. 5mm. longa, oblongo-lanceolata vel obovato-oblonga, fragilia, acuta, apiculata; lamina dorsalis ad folii basin angustata, paullo decurrens; lamina vaginans circa $\frac{1}{2}$ folii longitudinem aequans; costa sat valida, *concolor*, *paullo infra apicem desinens*; margines integrae seu minutissime crenulatae; cellulae obscurae, haud opacae, *parvae*, 6-8 μ latae, hexagonae parietibus firmis, tenuibus, chlorophyllosae, plerumque *seriebus obliquis e nervo radiantibus* dispositae; unaquaque dorso *papilla alta singula* praedita. Inflorescentia heteroica; flos $\hat{c}$ aut axillaris aut acrocarpus, aut in ramulo axillari brevissimo terminalis. Seta *brevissima*, 1-1. 5 mm. alta, ideo theca saepe folia suprema vix superante; rubella; sporangium operculatum setae longitudinem fere aequans; theca *turgide ovalis*, erecta, pachydermata sicca sub ore vix constricta, operoulo *acute recte anguste rostellato*; peristomium majusculum dentibus intense rubris, laevissimis, cruribus interne nodosio-incrassatis. Spori *maximi*, 27-30 μ, sublaeves. Calyptra minuta, sub-conica, mitraeformis, *per totam longitudinem scabra*.

Hab. On twigs of trees in very wet evergreen, Gairsoppa Falls (6463). A very remarkable little species, closely fringing the small twigs on which it grows; the extremely short seta, so that the capsule barely reaches above the floral leaves, the very large spores and highly papillose calyptra are most unusual features, perhaps unequalled in the genus.

The $\hat{o}$ flower seems highly variable in position, and I have found a fruiting stem innovating from the apex of a stem with a terminal $\hat{o}$ flower.

§ Pachyfissidens.

Fissidens Sedgwickii Broth. and Dixon. On stones in forest, Castle Rock (3417) c. fr.

CALYMPERACEAE.

Syrrhopodon semiliber (Mitt.) Besch. Twigs of trees, Siddhapur; alt. 1500 ft. rainfall 120 in. (6440).

This apparently extremely rare species has only been found hitherto, I believe, by Parish, near Tavoy, in the Malay Peninsula. The present plant agrees exactly with Parish's plant at Kew. Mitten placed it under Calymperes but Bescherelle in litt. ad Paris refers it, no doubt rightly to Syrrhopodon; the developed peristome points to this genus, and the calyptra also. Mitten describes the calyptra as "thecam ad collum obtegente et basi eam amplexante"; but he must have been misled by an immature or abnormal individual. Among some three dozen capsules in the Kew specimens there are none showing the calyptra as described; the calyptra is purely that of Syrrhopodon, and in the mature capsule reaches only about one-third of the way down; it is perfectly free at the base, and falls off before the lid. The plant is a true Syrrhopodon.

It may be worth mentioning that Mitten's citation of "Rev. D. Parish" throughout the Musci Indiae Orientalis is incorrect. It should be "Rev. C.S.P. Parish."

Calymperes Nietneri C.M. Var. nov. **atro-viride** Dixon.

Nigro-viride; folia sicca magis crispata, circinato-incurva, minora, breviora, leniter tantum dentata.

Hab. On tree, Siddhapur; 1600 ft. alt.; rainfall 120 in. (6482).

A marked variety but the characters seem insufficient to found a new species.

Calymperes Fordii Besch. Decayed tree trunk, Siddhapur, (6486) c. fr. Seems to be a slender form of this rather unsatisfactory species. It is rather curious that the only three species of this interesting family should have been collected all at Siddhapur.

POTTIACEAE.

Hymenostomum edentulum (Mitt.) Besch. *On Ixora parviflora* Konankeri, Dharwar District (3510) c. fr.

Hyophila involuta (Hook.) Jaeg. Syn. *Gymnostomum involutum* Hook. Musc. Exot, t. 154 (1820). *Gymnostomum cylindricum Hook* in Lond. Journ. of Bot. 1840, p. 2. *Hyophila cylindrica* Jaeg Adumbr. I, 204. *Hyophila stenocarpa*, Ren. and Card. in Bull. Soc. roy. bot. belg. 1899, p. 218.

Numerous gatherings; all c. fr.

I have examined the types of Hooker's *Gymnostomum involutum* and *G. cylindricum*, and I am unable to find any distinction. Hooker possibly was misled by an error he had made in the figure of *G. involutum*, where he depicted the leaf as entire whereas in the type specimen it is actually denticulate, as in *G. cylindricum*. The degree of involution of the leaf margin when the leaves are in the moist condition varies very much in different specimens, and probably according to the age of the leaf, and too much reliance must not be placed on this as a separating character.

After examining a large number of specimens that would come under *H. tenocarpa* Ren. and Card. I have finally come to the conclusion that it cannot be retained, at any rate as a species. It was founded, somewhat tentatively, as distinct from *H. cylindrica* on the strength of the taller stems, and the leaves scarcely involute when dry; the narrower, longer capsule, with a finer and longer beak to the lid. All these characters, however, I find very variable; this applies very markedly to the form of the lid, which in the type of Hooker's *G. involutum* (Nepal, Wallich) shows lids from short and obtuse to almost twice the length and finely subulate; and in the South Indian plant the form of capsule and lid are so variable that I can draw no line of distinction between *H. stenocarpa* and *H. involuta*. The plants vary very much also in size, and length of stem.

In all probability further reductions will have to be made in the genus.

Hyophila Walkeri Broth. Stones, Karwar (6366) c. fr.

The nerve is described as percurrent or very shortly excurrent while in Sedgwick's plant it rarely reaches quite to the apex. But I find this to be equally the case, frequently at least in original specimens of *H. wakeri* at Kew.

Barbula consanguinea (Thw. and Mitt) Jaeg., forma.

Bole of coconut palm, spice gardens, Shiggaon (3487).

Although a tall, sterile plant, with the stems 2 cm. high, and therefore differing considerably in habit from the normal plant, the structural differences are very slight (leaves a little narrower below, wider and less acute at apex) and I think it is certainly a form of *B. consanguinea*.

Barbula dharwarensis Dixon sp. nov. (fig. 7).

Sordide virens, caespitosa, terrestris; caulis circa 1cm. altus; folia *ebasi paullo dilatata lingulato-lanceolata*, apice *plano, obtuso, vel subacuto apiculato, margine altero inferne leniter recurvato*, ceterum plano, integero; patula, sicca crispato-incurva, 1—1.5 mm. longa. Costa

valida; in apiculum brevem excurrens, dorso *plus minusve grossiuscule ruguloso*. Cellulae subpellucidae, subquadratae, 5-7 μ latae, leniter papillosae, basilares sensim elongatae, laxiores; infimae laxiusculate subhyalinae. Cetera ignota.

Hab. Earth-bank in compound of rest-house, Nigadi, seven miles west of Dharwar (5703).

Belonging to the group of § Helicopogon having the back of the nerve strongly scabrous; near to *B. consanguinea* (Thw. & Mitt.), but, that has the leaves tapering to a point subcucullate at apex; here they are broadly lingulate, only the upper ones at all tapering to the point, and quite plane; *B. flavescens* Hook. and Grev. and *B. louisiadum* Broth, have narrower, longer leaves with much smaller cells. The leaves are remarkably like those of the European *B. unguiculata*, except in the rugulose back of the nerve.

Barbula indica (Hook) Brid, **forma sterilis** Fleisch. On a wall Sampkhand (6432).

BRYACEAE.

Brachymenium turgidum Broth & Dixon. Nov. var. **nanum** Dixon.

Densissime, humillime caespitosum; partibus omnibus eis *B. turgidi* simillimis sed multo minoribus.

Hab. On mango, Tadas, Dharwar District, 2,400 ft. alt.; rainfall 35 in. (5373); on bark of *Ixora parviflora*, Konankeri Dharwar, rainfall 35 in. (3509); on mango trees, near Dharwar (3591). All c. fr.

An exact miniature of *B. turgidum*, agreeing in all structural details, peristome, size of spores, etc. It is not in any way a starved or undeveloped state; the fruit is well formed only smaller than in the type, and with somewhat shorter seta. It appears to be an adaptation to the drier conditions; the three specimens were all collected under a rainfall of 35 in., and the type was not found at all; on the other hand Mr. Sedgwick has sent me the type from numerous localities round about Mahableshwar, with a rainfall of 250 in. or over.

Bryum argenteum L. var. **australe** Rehm. On a wall, Shiggaon (3486).

BARTRAMIACEAE.

Philonotis mollis (Doz & Molk) *Bry. jav.*—On stone in a stream, Sampkhand (6435). Earth bank, Malamane Ghat; 1000 ft. alt; rainfall 202 in. (6473) c. fl. ♂. On bank in shade, Siddhapur, alt. 1600 ft. rainfall 120 in.

NECKERACEAE.

Pterobryopsis Walkeri.—(Broth) Broth.

Castle Rock, (5521.) On exposed rock, Guddahalli Hill, Karwar (6387). The latter a form with the leaves longly cuspidate. Both sterile. Among some plants from Mahableshwar, one, No. 4716, was in fruit. Brotherus describes the perichaetial bracts as "integerrimae." They are abruptly contracted from a broad, sheathing base to a long, rigid, loriform subula; this is entire, but the shoulder of the basal part is often coarse and irregularly toothed, though not always so. I find the same to be the case with the Mysore plant, leg. Bretandean, det. Brotherus (Herb.Levier No. 44).

Pterobryopsis Maxwelli.—Cord. & Dixon.

Rocks in stream, Sampkhand (6433, 6434); trees on exposed hill summit, Guddahalli, Karwar (6388); twigs in very wet evergreen, Gairsoppa Falls (6466) c. fr.; trees, Caste Rock (5516, 5518, 5519) c. fr; trees, Anmod, (3310, 3311, 5376).

Barbella rufifolia.—(Thw. & Mitt.) Broth.

Hanging from trees, Siddhapur (6488). A bright green form with scarcely any of the reddish colour of the normal form; but I find no structural difference.

Neckeropsis andamana.—(C. M.) Fleisch.

On sapling, Siddhapur (6484).

Pinnatella calcuttensis (C. M.) Fleisch.

Numerous gatherings of this were made, mostly sterile, but here and there fruiting.

Pinnatella limbata.—Dixon sp. nov. (§Urocladium). (fig. 8)

Rupicola; *perrobusta*; caulis primarius repens, nudus, rigidus, caulis secundarius elongatus, ad 4-5 cm. longus, irregulariter, saepe *dense pinnatim* ramosus, ramis *crassis*, nec compressis, *flexuosis*, densifoliis, *obtusis*; folia patentia concava, sicca *et plicata et irregulariter rugulosa*, haud crispato-incurva 2. 5-3mm. longa, basi late ovata, nec deltoidea (1. 5 mm. lata) late oblongo-lingulata, apice late acutato, irregulariter denticulato; costa sat valida, longe infra apicem soluta, Cellulae superiores parvae, rhomboideae, latitudine variabili, saepe sigmatoideae, parietibus firmis; laevibus; marginem versus saepius seriebus nonnullis longiores, lineares, *marginales ipsae seriebus circa duabus bistratosae, breviores rhomboideae, chlorophyllosae, limbum angustum, incrassatum e basi ad apicem* instruentes. Cellulae basilares sensim longiores, linearea, flexuosae, ad angulos paucae latiores, subrotundae, parietibus incrassatis, sinuosis. Cetera ignota.

Hab. Rocks in stream, Sampkhand (6437).

Probably the most robust species of the genus; resembling *P. Gollani* in habit but quite different in structure,

Limbella marginata C.M., and *L. sikkimensis* Ren. and Card. appear to me to belong here and not to Neckeropsis; they have some resemblance to the present species, but they differ in the flattened branches, the less robust habit, and in the thickened border of the leaves being formed of elongate cells, longer than the interior ones, while here the marginal cells are markedly shorter and chlorophyllose.

ENTODONTACEAE.

Symphyodon Perrottetii Mont., forma **myuroclada.**

Trees, Anmod (3263). On bole of *Calophyllum*, Sampkhand (6442). Also gathered at Mahableshwar (4750, 4761). A very peculiar form, with long parallel branches, which are slender and julaceous, of a dark reddish brown or olive green colour. It is so unlike the ordinary form that I should hesitate to place it here were it not that some plants appear to intergrade with the typical form, and I can find no structural differences. Fruit would no doubt decide the position, but all the specimens are sterile; the species in fact I think is rarely found in fruit.

Entodon plicatus C. M. On trees, Anmod (3308). Trees, Lingmalla, 4000 ft. (4664); both c. fr.

Trachyphyllum inflexum (Harv.) Gepp. On bole of cocoanut palm in irrigated spice gardens, Shiggaon (3484). On bark of tree Konankeri (3518).

New to South India. Capt. Potier de la Varde in Rev. bryol., 1920, p. 20, records it from Cambodge.

Distrib. Nepal, Sikkim, and the greater part of the Malay Peninsula.

Stereophyllum anceps (Bry. jav) Broth. Bark of *Ixora*, Konankeri (3507). Also collected on trees, Mahableshwar, in 1917 (4759). Both sterile. Hitherto known only from Java. Sedgwick's plant agrees quite well with a specimen in Hampe's herbarium, misit Lacoste.

HOOKERIACEAE.

Collicostella papillata (Mont.) Jaeg. f. **purpurascens.**

On stone in stream, Sampkhand (6439). A very pretty form, all the leaves being tinged with a deep purple red colour. No fruit was seen.

Lepidopilum rhaphidostegium (C.M.) Broth. Twigs of tree in very wet evergreen, Gairsoppa Falls (6464) c. fr. A very interest-

ing discovery, as the plant has hitherto been recorded only from an unlocalized habitat in Java, and from Celebes (Herb. Lacoste). I have not been able to compare it with either of the original specimens, but it agrees quite well with Fleischer's description, and with the figures in the Bry, jav., &c.

THUIDIACEAE.

Thuidium trachypodum (Mitt.) Bry. jav. Stones in stream, in dense evergreen Guddahalli Hill, Karwar (6400) st. On stone in stream, Jog (6470)c. fr. Both of these represent an extremely small, densely caespitose, rather rigid form. The fruit however agrees quite well with *T. trachypodum*. *T. sparsifolium* (Mitt.) is much like it, but apart from the almost smooth seta is larger, with slightly less obtuse. leaves. Does *T. Brotheri* Salm, differ from *T. sparsifolium*? I cannot detect any difference, (apart from the doubtful question of inflorescence).

HYPNACEAE.

Ctenidium stereodontoides Dixon sp. nov. (*fig. 9*).

Late *dense intricate* caespitosum, *molle*, juventute laete-virens, nitescens, aetate rufo-fuscescens. Caules prostrati, intertexti, flexuosi, *irregulariter,—hic illic dense—pinnati*, ramis inaequalibus, flexuosis, *apice subfalcatis*, *penicillatis*, paullo compressis. Folia confertiuscula, *undique patentia vel leniter falcato-decurva*, *haud squarrosa*, *sicca valde flexuosa;* leniter plicata, *oblongo-lanceolata vel anguste ovato-lanceolata*, apice valde angustato, subpiliformi, subfalcato, plus minusve argute denticulato; costa plerumque subnulla, marginibus planis, usque ad basin fere plus minusve denticulatis. Folia ramea similia, paullo minus anguste acuminata, apice argutius denticulata; cellulae peranguste lineares, echlorophyllosae, dorso haud prominentes, basin versu *parum latiores*, paullo breviores, ad angulos *perpaucae* isodiametricae, parvae, 1-2 ad alas extremas majores, quadratae, hyalinae.

Dioicum. Flores ♀ juniores solum visi.

Hab. On stones in stream, Sampkhand (6445).

Distinct from the other Asiatic species in the habit, which with the falcate-decurved leaves is rather markedly Stereontoid; in the position of the leaves and their outline, very little widened at base. It is perhaps most like *C. polychaete* (Bry. jav.); but that has leaves more ovate below, and deeply cordate at base, which is not at all the case here.

Ectropothecium compressifolium (Mitt.) Jaeg. Rocks by a small waterfall, N. Kanara forests, 1400 ft. alt., rainfall 150 in. (6450) st.

This differs from the usual Himalayan plant in having the cells rather narrower and more opaque, and distinctly spiculose at back; there they are either smooth or very slightly spiculose. As the species has not been recorded from Southern India it might be thought that the difference should warrant its being separated specifically or subspecifically. But I have received a plant from the New York Bot. Garden ex herb. Mitten "Ectropothecium rotatum Mitt. MS.; Koond, in rup, rorant., No. 55, Griffith," which must be referred to *E. compressifolium*, but agrres with Sedgwick's plant in areolation entirely. I have not been able to locate "Koond," but it is clearly in northern India, and therefore connects No. 6460 and the type of *E. compressifolium* admirably.

Taxithelium nepalense (Harv.) Jaeg. (Syn. *T. turgidellum* (C.M.) Par. *Hypnum turgidelium* C.M. in Engl. Bot. Jahrb. vol. V, p. 87 (1884).

Guddahalli, Karwar (6402). On stones in stream, Sampkhand (6451). Stones, Anmod, (3422); trees, Anmod (3264). All c. fr.

The last two numbers represent a very fine form; robust, with leaves much less distinctly papillose than in the usual forms; 3422 however is somewhat nearer the type; and other plants of *T. nepalense* which I have examined show so much variation than I do not think it can be given varietal rank.

T. turgidellum (C.M.) is intermediate between No. 3264 and the type, and is quite inseparable from *T. nepalense*.

Vesicularia Levieri Card. MS. in Herb. Sp. nov. (fig. 10).

Sat *robustum* Caules usque ad 8cm. longi, subregulariter, confertiuscule pinnati, ramis fig. *1 cm. longis vel paullo ultra;* folia conferta complanata, sicca leniter contracta. subdecurvata, *majuscula* 1. 5mm. longa, dorsalia et ventralia ovato-lanceolata., acuminata, subfalcata, lateralia *late ovata, breviter nec anguste acuminata*, apicem versus *denticulata*, costis binis brevissimis; cellulae laxae, foliis lateralibus 14-17 μ latae (4-5 X 1), parietibus firmis.

Fructus haud visus.

Hab. Ins. Andaman merid,; Port Blair, leg. E. H. Man 1893, (*Ectropothecium reticulatum* in Herb. Levier, no. 5138). Dharwar District, N. Kanara (7279), leg. Sedgwick.

Near to *V. reticulata* (Doz. & Molk.) but more robust, and with leaves decidedly less longly and finely acuminate, less toothed above, and cells rather narrower and firmer.

Man's plant was distributed as *Ectropothecium reticulatum* by Levier, Bryoth. exot., No. 90.

The other Indian species are distinguished at once by either their smaller size, more acuminate lateral leaves, or much wider cells.

LEUOMIACEAE.

Leucomium aneurodictyon (C.M.) Jaeg.

Dharwar District (7279b). Without fruit. Growing with *Vesicularia Levieri*. It has not, I believe, been recorded from the Asiatic continent, but is probably a plant of much wider distribution than that usually attributed to it (Sumatra, Java, Borneo); I have a plant from Australia, ex herb. Mitten, probably gathered by F Mueller, which I cannot separate from it, and it is probable that some of the species described from quite other parts of the world may have to be brought under it.

L. limpidum Thw. and Mitt. from Ceylon, differs in the synoicous inflorescence and in the leaves scarcely contracted when dry.

SEMATOPHYLLACEAE.

Trichostelium monostictum (*Thw. and Mitt*). Broth. Bark of fallen tree, Sampkhand (6441) c. fr.

Explanation of Plate.

Fig. 1. *Archidium birmannicum*. a, stem leaf; × 20; b, branch leaf, × 20; c, leaf apex, × 50; d, d, upper cells, × 200.

Fig. 2. *Leucoloma strictifolium*. a, plant, in dry state, × 1; b, leaf, × 20.

Fig. 3. *Fissidens subfirmus*. a, leaf, × 20; b, apex of leaf, × 50; c, upper cells, × 200.

Fig. 4. *Fissidens karwarensis*. a, leaf, × 20; b, apex of leaf, × 50; c, upper cells, × 200.

Fig. 5. *Fissidens immutatus*. a, leaf, × 20; b, apex of leaf, × 50; c, upper cells, × 200.

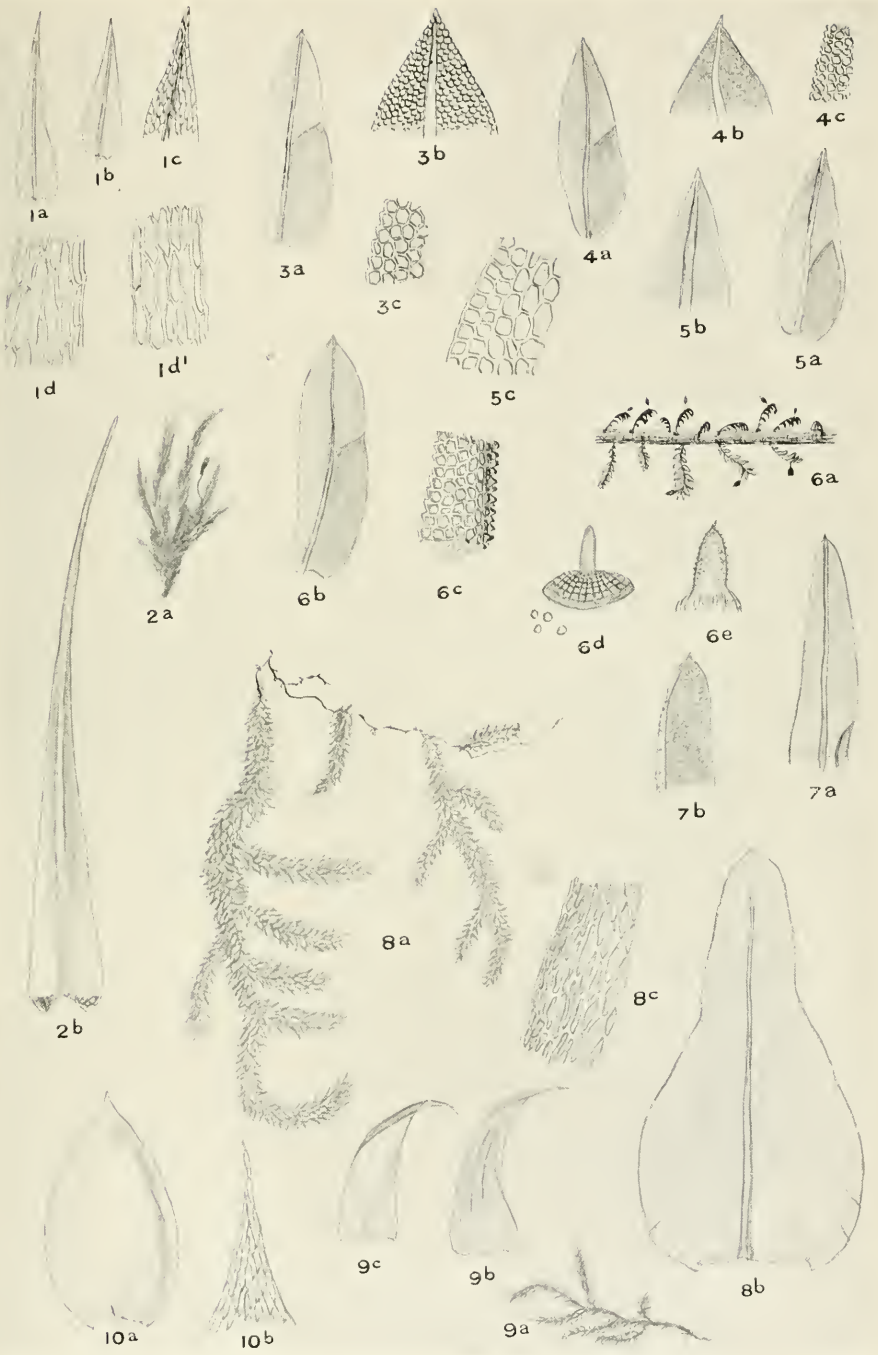
Fig. 6. *Fissidens macrosporus*. a, plant, × 1 (above, dry; below, moist); b, leaf, × 20; c, upper cells, × 200; d, lid and spores, × 30; e, calyptra, × 30.

Fig. 7. *Barbula dharwarensis*. a leaf, × 20; b, apex of leaf, showing nerve in profile, × 50.

Fig. 8. *Pinnatella limbata*. a, stem (dry), × 1; b, leaf, × 20; c, upper marginal cells, × 200.

Fig. 9. *Ctenidium stereodontoides*. a, part of stem, × 2; b, stem leaf, × 20; c. branch leaf, × 20.

Fig. 10. *Vesicularia levieri*. a, lateral leaf, × 20; b, apex of dorsel leaf, × 40.



del. H. N. Dixon.

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NORTH KANARA MOSSES.

A NEW GRASS CHLORIS BOURNEI Sp. Nov.

By K. Rangachariar and C. Tadulingam

Agricultural College, Coimbatore

Chloris Bournei *Rangachariar* and *Tadulingam.* (Graminaceæ—Poaceæ—Chlorideæ) C. barbata *Sw.* affinis, sed majore spicula glumis cum 3-5 awnibus, et nervis hirsutis, differt. Herba perennis. Culmus crassus, 1-3 pedibus longus. Nodi purpurei. Folia linearia, glabra. Pedunculi ad quindicun digiti alti. Spici crassi, purpurei. Spiculæ 3 m.m. longae. Glumæ cum 3 aut 4, sæpe 5, awnibus. Awnes 5-7 m.m. longi. Flores feminei sæpius cum 2 aut 3 granibus. Nerva tertiæ glumæ apice basim hirsuta.

Loc. Coimbatore, on black cotton soil. *Herb. Madras.—1317, 1318, 4443, 5348, 6166, 6569, Coll. K. Rangachariar.*

This grass is perennial. The stems are somewhat stout, tufted, erect or ascending geniculately from a creeping and rooting base varying in length from 1 to 3 feet, with internodes 2 to 6 inches becoming longer upwards; nodes are thickened, deeply purple-ringed, glabrous and the lower nodes always with a fan-like tuft of flattened leaf-sheaths and leaves.

Leaf-sheaths are equal to or longer than the internodes at the base, but shorter above, glabrous, compressed, distichous, bearded towards the mouth and with membranous margins. The ligule is a narrow membranous ridge.

Leaf-blades are liner, finely acuminate, slightly broadened and rounded at the base, keeled, the upper surface scaberulous and with a few scattered long hairs especially towards the base, smooth or slightly scaberulous below, 1 to 9 inches by 1/12 to 1/4 inch.

The inflorescence consists of digitately arranged spikes 1 1/2 to 4 inches long on a peduncle which is sometimes 15 inches long; spikes are stout, purple-tinged, 3 to 7 and even 9 in some specimens, shortly stalked, the base of the stalk being slightly swollen and villous at the base; the rachis is slender, somewhat villous towards the base. Spikelets are about 1/8 inch excluding the awn, very shortly pedicelled, biseriate, unilateral, disarticulating above the first two glumes which are persistent, purplish or pale, 1 to 3-flowered, usually 3 to 4-awned and sometimes 5-awned; awns are purplish 3/16 to 5/16 inch long, finely scabrid. There are 5 to 7 glumes in a spikelet. The first glume is hyaline, purplish or pale, about 1/10 inch long, lanceolate, subacuminate, 1-nerved with a scabrous keel; the second glume is hyaline, about one and a half times as long as the first, oblong

elliptic, minutely 2-lobed at the apex with a minute mucro between, I-nerved with a scabrid keel. The third glume is as long as the second, awned, pale or purple, ovate or obovate, narrowed at the base and clasping the rachilla at its base; apex shortly 2-fid with a purple dorsal awn, 3-nerved, paleate, the two marginal nerves are densely bearded with long white or purple tinged hairs from near the base to almost the apex and the mid-nerve also similarly bearded with long hairs on both sides, and the base with a tuft of long hairs; the palea as long as the glume, coriaceous, obovately cuneate, obtuse, minutely bifid, purple-tipped, with folded hyaline margins, 2-keeled, keels shortly ciliate. Stamens three with yellow or purple anthers; ovary with two feathery stigmas and two lodicules. Grain is oblong, shining, light reddish brown, narrowed at both ends and somewhat trigonous. The remaining glumes, fourth to seventh, are borne by the rachilla, thinly chartaceous, broadly obcordate or obovate, gradually diminishing in size, purple-tinged, 3 to 5-nerved, scaberulous. The fourth and the fifth glumes are empty and epaleate when the spikelets are 5-glumed. If there are six glumes, the fourth bears both stamens and the ovary, the fifth and the sixth glumes are empty, and in spikelets of seven glumes, the third, the fourth and the fifth glumes are flower-bearing and contain grains, and the remaining two glumes are empty.

This species is a tall-growing robust one resembling *Chloris barbata* in its inflorescence, but with longer spikes and larger spikelets, as large as those of *C. tenella*. No doubt, it is closely allied to *C. barbata*, but differs from it by having larger spikelets that are 3 to 5-awned and 1 to 3-flowered, and the nerves being bearded throughout their length with long hairs.

This grass was found growing in abundance in the fields Nos. 13, 37 and 62 of the Agricultural College and in the grounds around the Forest College, Coimbatore, and was also collected in Bellary District and Samalkota.

Specimens of this grass were sent to Dr. O. Stapf of Kew and he writes as follows:—

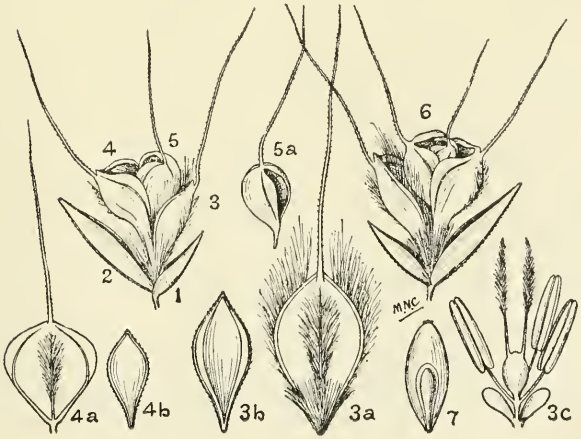
"We have not been able to match it with any of the described species of Chloris, and Mr. Rangachariar will be fully justified in describing it as a new species. We have it apart from Wight's specimen from the following collection:—

(1) Sattur, November 19, 1795 sub "Andropogon barbata Var.?" Herb. Rottler.

(2) Ahmednagar, Madras Presidency, Miss Shattuck (U. S. Dep. Agric. recd 1914).

(3) Tornagallu, Bellary District 11th August, 1901 (Ex. herb. Rangachariar in Herb. Bourne No. 3594).


2
1


4
5
3
2
1
5a
6
4a
4b
3b
3a
M.NC.
7
3c

THE INDIAN SPECIES OF ERIOCAULON

By P. F. Fyson, M.A., F.L.S.,
Presidency College, Madras.

(*Continued from p. 150.*)

I. SETACEAE.

Submerged plants. Stem slender elongate and often branched, bearing leaves for several inches. Leaves very slender, or capillary, 1-5 in. long. Head numerous, 1/10 to 1/16 in., on slender peduncles usually in a terminal umbel, but often also from more than one node. Receptacle glabrous or hairy and chaffy with adherent bracts. Sepals of the male more or less free. All parts of both sexes in threes; stamens 6; anthers black.

Though placed first for convenience because differing from the rest of the genus in their very pronounced aquatic habit and elongated stem, the species which comprise this group should almost certainly be regarded not as primitive, but as aquatic offshoots from the original stock, to which the next group, SIMPLICES, are nearest.

A difficult group to work out in old collections, the heads and the flowers being small, and some confusion has crept in with regard to the species. Linnæus in Sp. Pl. Ed. 1. 1753 p. 87 founded *E. setaceum* on an Indian plant giving as synonym *Randolia malabarica* and quoting also Rheed. Mal. [Hortus Malabaricus] 63. He mentioned only the 6-angled stem and capillary leaves. In Fl. Zeylanica (1747) p. 50 he had mentioned in addition the membraneous sheath and submerged roots.* Steudel in Syn. Pl. Cyp. (1855) took this species to be the one with glabrous floral bracts, that being the common Malabar plant. Koerniche in Linnaea XXVII p. 603 took the hairy species as Linnæus' *E. setaceum* and founded *E. intermedium* for the glabrous form on a sheet of Wight's, No. 2369. He considered that Linnæus had been in error in quoting Rheede's figure for *E. setaceum*. Hooker in F.B.I. appears to have reverted to Steudel's conception of the glabrous plant for *E. setaceum* for he described the floral bracts as black and glabrous and founded the new species *E. capillus-naiadis* for the hairy heads. He also identified forms with glabrous heads and glabrous, not villous, receptacles as *E. bifistuloseum* Van Hueren a West African species. Ruhland l.c. reinstated the hairy heads as of *E. setaceum* Linn., reducing Hooker's *E. capillus-naiadis* to that species, and restored *E. intermedium* Koern., at the same time confining *E. bifistuloseum* Van Hueren to West Africa. I find young heads often glabrous, though hairy when fully developed, and that it is impossible to determine with certainty whether the receptacle is grabrous or not, for it is often covered with short scales. I find also that the female petals vary in regard to the position of the gland, which may be well inside the margin as with other species or on it.

It seems however probable that there are in India only two species. *E. setaceum* L. with hairy and *E. intermedium* Koern. with glabrous bracts, and that other differences are casual variations. I have not seen Linnæus type

* I am indebted to Col. Gage, I.M.S., Director of the Botanical Survey, for the copy of Linnæus' descriptions, etc. from which this is taken.

plant but assume that Ruhland did, and follow him and Koerniche in identifying the hairy heads as all *E. setaceum* Linn.

Floral bracts hairy, heads gray or white ... E. setaceum.
Floral bracts glabrous, heads black ... E. intermedium.

1. **Eriocaulon setaceum** L.; Ruhl. No. 134.; E. capillus-naidis in F. B. I. vi 572, No. 23. Stem slender, up to 15 inches long (? or more), covered in at least the upper part with long linear leaves. Scapes umbelled at the summit of the stem. Heads 1/6 in. diam., conical, gray or white. Floral bracts acute, with short white hairs on the backs. Male flowers: sepals 3 free or nearly so; corolla lobes small; anthers black. Female flower: sepals 3 boat-shaped, concave round the seeds; petals 3, oblanceolate with distinct glands. Plate 1.

Assam; Khasia hills: Burma: Ceylon.

In some the female petals are ciliate and with distinct gland well inside the margin; in others they are glabrous with apical gland and distinct midrib.

2. **E. intermedium** Koern.; Linnaea XXVII p. 601; Ruhl. l.c. No. 135; F. B. I. probably E. setaceum and E. bifistulosum.

Similar in habit to E. setaceum *Linn*, but the floral bracts glabrous, making the heads black. Flowers as in E. setaceum, but female petals unequal. Plate 2.

[?] Assam; Khasia: Peninsular India; Malabar: Ceylon.

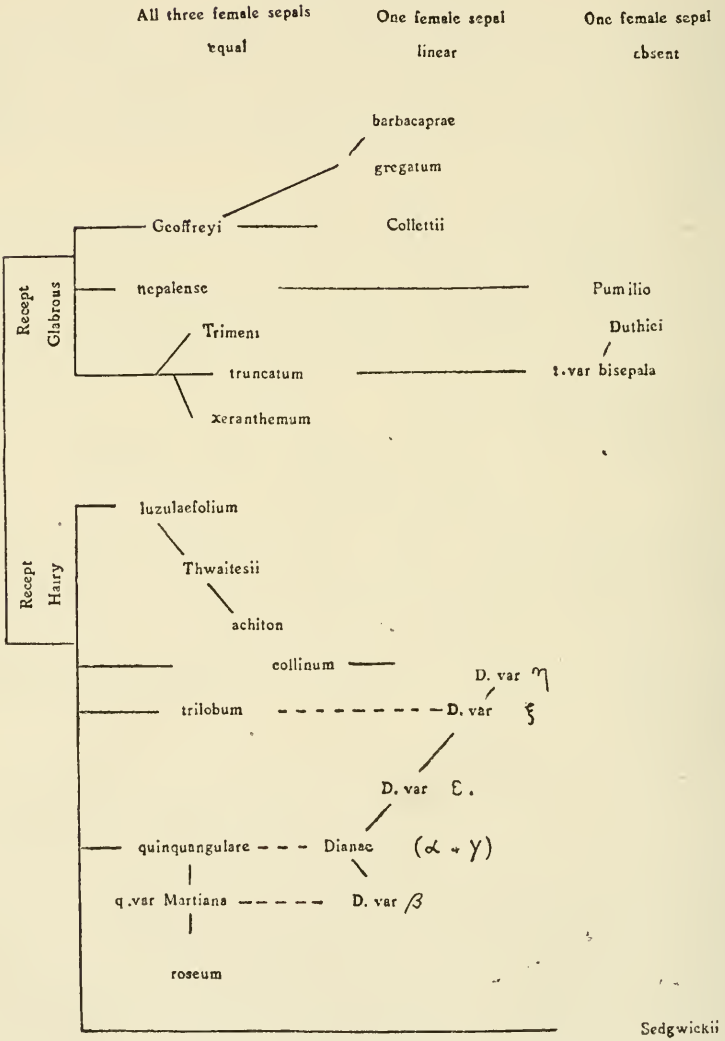
II. SIMPLICES.

Stems usually disciform, (O), but in some species branched but short, and in most tufted. Leaves usually short, the plants growing in marshy ground or still water, glabrous. Scapes tall. Heads 1/2 in. or less. Involucral bracts black with pale (colourless or yellow) base; usually reflexed or horizontal, sometimes extending far beyond the general outline of the head. Floral bracts usually black, but covered often so densely with white hairs that the heads are white or gray. Receptacle glabrous or villous.

As noted above in the Introduction (pp. 142, 146), some of the species of this second section show remarkable variation of the female sepals with locality. There also appears a progressive lengthening of the involucral bracts as the species pass southwards*. Thus on the Western Ghats *E. Dianae* has near Bombay bracts scarcely longer than the head, and further north bracts actually shorter and reflexed; but where more typically developed has the bracts distinctly longer, and in Calicut several times or long as the head, approaching *E. xeranthemum*. Throughout the forms are connected by intermediates. On the other side of the Bay of Bengal there appears to be a similar series, but with a fewer stages collected. They differ from their like as the Western Ghats by the female sepals all being equal, whereas in the latter one sepal is narrow or reduced to a bristle.

* A similar lengthening of the involucral bracts is shown in other sections; see *E. cuspidatum E. Edwardii* and *E. lanceoalatum.*

TABLE OF PROBABLE RELATIONSHIPS



SPECIES OF ERIOCAULON § SIMPLICES.

In the table opposite giving the scheme of probable relationship the reduction of one female sepal is shown to have occurred four times and the total loss of a sepal three times. The most involved relationships are shown in the group near the bottom of the diagram. It will be seen that *E. Dianae* is through its varieties connected apparently both with *E. quiquangulare* and with *E. trilobum*. The three species form in fact a closed ring, and the first two with their varieties form a second ring. How this can have come about through descent, I do not propose to discuss here; the facts however are that the species or varieties shown connected by dotted lines are almost or quite indistinguishable except by the character of the one linear sepal, and those shown connected by firm lines are clearly related.

E. xeranthemum and *E. truncatum* with the female sepals 2 or 3, and *E. collinum* with them equal or unequal, contain within themselves the reduction of one sepal.

Key to the Simplices.

(a) Receptacle glabrous.

* Female sepals 3.

† Female petals broadly oblanceolate or spathulate with large black glands.

Scapes 10-15 in; heads 1/2 in; female petals visible beyond the bracts (Burma) ... 4 E. Collettii.

Scapes 1/2-2 in; solitary or clustered; heads 1/3 in. (S. Indian Hills) ... 3 E. Geoffreyi.

Scapes 4-5 in., heads 1/4 in. stems branched densely tufted; leaves 2-3 in., linear, (Shillong) ... 5 E. barba-caprae.

Scapes 2-3 in., tufted; leaves 1-1/2 in., linear; heads 1/6 in. (Khasia) ... 6 E. gregatum.

†† Female petals narrow, with small or no glands; or absent.

Scapes 4-6 in.; heads 1/6-1/4 in., globose ... 7 E. nepalense.

Scapes 1-2 in.; heads 1/8 in., do. ... 8 E. Pumilio.

Scapes 1-1/2-2 in.; leaves 1/3-1-1/4 in., heads 1/6 in. truncate at base (Ceylon) ... 9 E. Trimeni.

Involucral bracts twice as long as the head. 12 E. xeranthemum.

** Female sepals 2, rarely 3.

Scapes 2-4 in.; heads 1/4 in.; truncate by the very horizontal involucre (Assam to Malacca and to Ceylon) ... 10 E. truncatum.

Scapes 4-6 in.; heads 1/6 in.; bracts reflexed (Central Provinces) ... 11 E. Duthiei.

(b) Receptacle villous.

* Female sepals 3 all equally boat-shaped or flat.

† Ls. red or drying red.

Heads 1/4-1/3 in. diam., globose or ovoid (plains from Bengal to Ceylon) ... 15 E. quinquangulare.
Heads 1/8-1/4 in. diam.; bracts much longer. (Burma) ... 17 E. roseum.

† † Ls. not drying red.

† Involucral bracts, obtuse, horizontal.

Scapes 4-15 in. Female. petals oblanceolate (Khasia and N. Burma). ... 13 E. luzulaefolium.
Female petals linear, with long basal hairs, so brush-like ... 14 E. Thwaitesii.
No female petals, heads obconic ... 15 E. achiton.

‡ ‡ Involucral bracts reflexed, shorter than head; Heads 1/6 in. (Bengal) ... 19 E. trilobum.

Heads 1/4-1/3 in.
Involucral bracts reflexed, shorter than head; heads 1/4-1/3 in. (S. Indian Hills) ... 20 E. Collinum.

* * Female sepals 3, one flat or linear; heads grey (Ceylon) ... 20 E. Collinum.

Heads gray or white; involucral bracts short or long, horizontal or reflexed. (Western Ghats). ... 21 E. Dianae.

* * * Female sepals 2.

Scapes 4-8 in. Involucral bracts not longer than floral; heads densely white villous. (N. Kanara) ... 22 E. Sedgwickii.

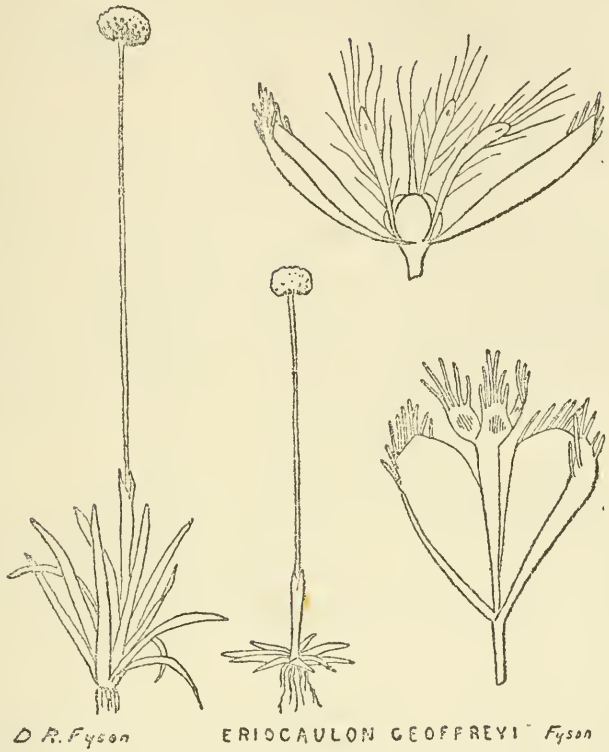
Sub-section (a).

3. **E. Geoffreyi** Fyson, Kew Bulletin Nov. 1914, p. 330; Flr. Nil. and Pul. Hill tops p. 432. Stem O. Leaves 1/2-2 in., flat tapering to the acute apex. Scapes solitary, in the type, or several, three or four times as long as the leaves. Heads gray; involucre black. Receptacle glabrous. Flowers regular, 3-merous. Petals unusually broad, the female spathulate with large glands. Fig. opp.

Peninsular India; on the Pulneys at 7000 ft.

The type plant was collected at 7500 feet on the Pulneys and is remarkable for the solitary scape rising from a rosette of stiff short leaves. It occurs all over the downs, not in particularly damp spots, and flowers in the autumn. What appears to be a dimerous variety of this species is on a sheet in Herb. Calc., dated July 5th, 1865 collected at "North Hastings."

4. **E. Collettii** Hook. f. (Chandler, Shan Hills, in Herb. Calc. marked "identified at Kew"); F.B.I. vi 575, No. 15; Ruhl. p. 114 "incognita."



Stem O. Leaves 3-5 in. by 1/3-1/2 in. at the base, many nerved, glabrous. Scapes several, 10-15 in., slender, glabrous. Heads 1/2 in. nearly globose, white; involucral bracts black, reflexed. Receptacle glabrous. Floral bracts acute. Female flr :—Sepals 2 boat shaped, 1 flat; petals longer, broadly oblanceolate or spathulate, with large glands, and protruding beyond the floral bracts. Male flower normal, petals with large glands. Plate 3.

Upper Burma and Shan Hills.

Hooker in F.B.I. placed the species among those with the male petal longer than the others and protruding beyond the bracts, possibly (if the plants taken above as this species are correctly so named) deceived by the very similar appearance of the female petals on the outside of the head. But the male petals are quite equal, and in other respects this appears to belong to this section.

5. **E. barba-caprae** Fyson, sp. nov. (Collett at Shillong 10/10/90 in Herb. Calc.) Caulis paulum elongatus et divisus hence plantae dense caespitosae. Folia 5-8 cm. longa, basi valde dilatata, linearia, acuta. Pedunculi plures, circe 10 cm. Capitulla 6 mm. Receptaculum

altum, glabrum. Flores tri-meres. Flos. ♂—sepala spathaceo-connata, nigra; lobi corollae, sub-equales; antherae nigrae. Flos ♀ sepala 2 navicularia, 1 planum; petala late-oblanceolata, glandulis magnis. Plate 4.

Assam, Shillong (Collett!)

Species valde distincta. Descriptione, *E. miserum* Koern. similis, sed antherae ilius species flavescentes (Ruhland l.c. 68).

I have seen only one sheet. The densely tufted linear leaves, black when dry, suggest the name 'goats-beard'. The receptacle is tall and the heads nearly globose, not as usual by the involucral bracts being reflexed, but by their sloping upwards; but this may be because the heads are young. It answers fairly well to the descriptions both of *E. mitophyllum* Hook. f. and *E. miserum* Koern., as quoted in F.B.I. and in Ruhland (l.c.); except that in the former the receptacle is globose and in both the anthers white. In appearance too the plant is different from what I take below to be these species.

6. **E. gregatum** Koern.; F.B.I. vi 581, No. 33; Ruhland No. 69. Stem slender, tufted, 1/2-1 in. Leaves 1-1-1/2 in. by 1/20 in., acute. Scapes solitary to each stem or branch, twice the leaves. Heads 1/8-1/6 in; involucral bracts obtuse, pale with broad black margin. Female flower: sepals 3, two boat-shaped, one flat; petals broadly oblanceolate, obtuse with large glands. Male flowers normal. Plate 5.

Khasia at 4-5000 ft.

7. **E. nepalense** Prescott (Fide Clarke No. 44827 in Herb. Calc.); F.B.I. vi 581, No. 32; Ruhland No. 130. Stem short or O. Leaves flaccid, flat, tapering from 1/8-1/4 in. base, 2-3in. long, acute. Scapes many, twice as long. Heads 1/6-1/4 in. nearly globular when mature. Involucral bracts black acute, receptacle glabrous. Sepals 3 all boat-shaped. Female petals narrow hairy, seeds oblong with pappilose ribs. Plate 6.

Assam; Khasia: and "from Garwhal to Sikkim." (F.B.I.)

I have not seen the type sheet and am relying on Clarke's plant quoted above, which appears to agree with the description in the F.B I. The female petals in it have glands, but Ruhland (l.c.) says of the species that there are no glands.

8. **E. Pumilio** Hook. f. (Duthie No. 4473 in Herb. Dehra Dun!) F.B.I. vi 581, No. 34; Ruhl. p. 116 'incognita'. Very small. Stem O, tufted. Leaves 1/4-1/2 in. acicular. Scapes 1 in. Heads 1/8. Involucral bracts obtuse, pale nearly or quite horizontal. Floral bracts cuneate-cuspidate, dark but hairy. Receptacle glabrous. Female fl: sepals 2, deeply boat shaped; petals 3. Male fl: normal. Plate 7.

Western Himalayas at 3-4,000 ft.; Kumaon and Gharwal at 8-9,000 ft. (F.B.I.): Nr. Ramri.

I have seen only the one specimen quoted above. The sepals are large, Ruhland says of the species that they are flat and concave only at the tips, but those of the specimen seen by me are quite boat-shaped for the whole length.



VARIATION IN FEMALE SEPALS.

Taken from a sheet of E. truncatum *Ham.* marked 47. D. Barclay, C. India, 1870.

9. **E. truncatum** Ham.; F.B.I. vi 578, No. 24; Ruhl. No. 178 Leaves usually 1-3 in. flat, narrowed from the base. Scapes several. Heads hemispheric. Involucre horizontal, scarious, not or hardly projecting beyond the head. Receptacle glabrous. Floral bracts very obtuse, nearly glabrous. Female sepals narrow, 2 boat-shaped, toothed at the apex, and third sepal if present acute; or 2 only. Petals 3 narrow.

Bengal, Assam, North Burma and southwards to Malacca; S. India and Ceylon.

Var. *a* vera, Tipperah, Mts. of Monghir.

This I take to be the true species, for Mart. in Wall. As. Rar. iii, p. 29 describes the flower as having a third sepal. But Koerniche in Linnaea xxvii, p. 633, Hooker in F.B.I. l.c. and Ruhl. l.c. both give the commoner 2-sepalled flower of the next variety.

Var *b* di-sepala. Female sepals 2, otherwise as in the type. The wider distribution given for the species.

For a similar variation in the female sepals see *E. Thwaitesii* Koern.

Two sheets in Herb. Calc. unfortunately without precise locality but one marked C. India, are similar in many respects, but the floral bracts are cuneate acute, not rounded. The female sepals vary in the same head, 3 equally boatshaped or one linear, or two only. Except for the glabrous receptacles these plants might be *E. Dianae.* (No. 20).

10. **E. Trimeni** Hook. f. (Bambulla Rk. 1881 in Herb. Ceylon !) Fl. Ceylon, 1900, v p. 8; Ruhl. p. 117, "incognita". Scapes 1/2-2 in. leaves 1/3-1/4 in. narrow to linear. Heads 1/10-1/8 in. Involucral bracts hyaline, as long or slightly longer than the floral, sub-erect. Floral bracts cunately oblong or obovate. Receptacle glabrous. Male flowers, sepals 3, but 2 connate; sta 6 (not 1). Female flowers, normal; seeds glistening yellow, smooth.

Ceylon.

Hooker l.c. compared this with *E. Sieboldianum*, but the black anthers and flatter head sufficiently distinguish it. Hooker also in error described the male flowers as having only one stamen. There are 6 quite clearly in the plant quoted above. It was referred to *E. truncatum* Ham. by Trimen, and though differing in its flower and in the involucre being less horizontal is clearly allied to that species.

11. **E. Duthiei** Hook. f. (Duthie No. 8436 in Herb. Dehra Dun !) F. B. I. vi 579, No. 22 ; Ruhl. No. 174. Stem O. Leaves 3/4 in. long, broadly oblanceolate acute from a 1/6 in. wide base. Scapes numerous 1 to 6 in. slender. Heads 1/6 in. Involucral bracts pale, not projecting beyond the floral. Floral bracts oblong cuspidate, nearly glabrous. Receptacle tall, glabrous or with a few hairs. Sepals 2 only, in both sexes. Female petals narrow, nearly glabrous. Seeds oval, yellowish brown with darker markings. Male flowers.— Sepals 2 ; otherwise normal, anthers black. Plate 7.

Central Provinces, one collection only seen.

The scapes are taller, the heads smaller and the involucres less horizontal than in *E. truncatum*.

12. **E. xeranthemum** Mart. (Wall Cat. 6081 in Herb. Calc !) F.B.I. vi 584, No. 43 ; Ruhl. No. 150 Leaves 2/3-1/2 in. Scapes slightly longer or shorter. Disc of head 1/10-1/8 in. Involucral bracts much longer, glistening white. Receptacle globose, floral bracts broadly obovate truncate, hairy at the tip. Female sepals narrow 3 equal or unequal or 2 only. Fig. opp.

Central Himalayas, Nepal; Assam, Khasia, Peninsular India, Malabar, Cochin, etc.

Hooker in F.B.I. describes the receptacle as hairy, but wrongly. Martius in Wall. Pi. As. Rar. Vol. iii says the hairiness is the only real reason for distinguishing *E. xeranthemoides* from this species. Hooker also gives the sepals as 2. Koerniche in Linnaea xxvii p. 626 gives them as 3, but unequal. I find both the petals and sepals of the female flowers vary in size among themselves and one sepal may be linear or absent.

13. **E. luzulaefolium** Mart. (Wall. Cat. 6071 in Herb. Calc !); F.B.I. vi 582, No. 35 in part ; Ruhl. No. 131 in part. Leaves 2-4 in. narrowed from the 1/6 in. base, flat, many-nerved. Sheaths about as long. Scapes many, 2 to 4 times as high, slender. Heads 1/4 in., truncate, clasped below by the light ? brown obtuse saucer shaped involucre. Floral bracts dark with white hairs, making the heads gray. Receptacle hairy. Sepals and petals three, narrow. Plate 8.

Central Himalayas, Nepal, Assam ; Silhet (type sheet !) ; Lr Bengal ; and the Shan States.

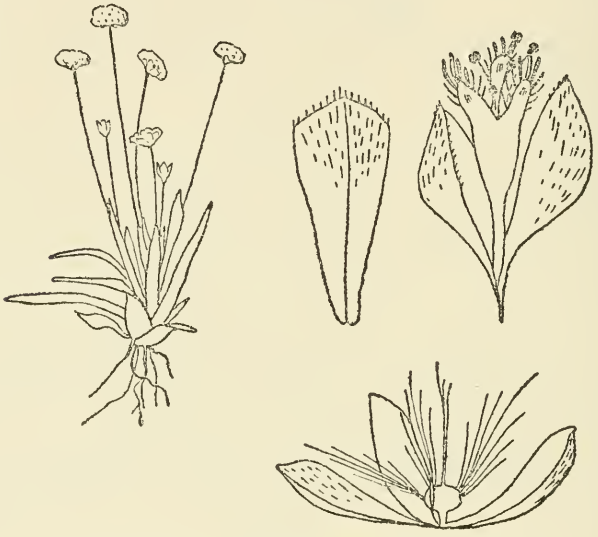
Hooker in F.B I. has a much wider distribution extending over all India, Ruhland merely repeats this. But the sheets seen by me with that name from Madras, Kanara and other parts are not the species of the above quoted type. The Ceylon plant C. P. 796, so named, has none of the characteristic truncate appearance of the head on a saucer-shaped involucre and is *E. collinum*. Wallich's plant quoted above does not in fact resemble *E. quinquangulare* as stated by Hooker.



M. V. Rungam. ERIOCAULON XERANTHEMUM. *Mart.*

14. **E. Thwaitesii** Koern. (C. P. 790 and 769 in Herb. Kew. and 790 in Herb. Calc.!); F.B.I. vi, 583, No. 40; Ruhl. No. 171. Leaves 1/2-2 in. oblong acute, flat. Scapes many, 1-6 in. of various heights. Heads 1/14-1/3 in. at first obconic, later truncate, dark gray. Involucral bracts very obtuse, pale. Receptacle hairy. Female sepals 3, equal and boat-shaped or 1 smaller or 2 only. Petals 3, very slender and bearing long hairs from near the base. Seeds oblong, brown.

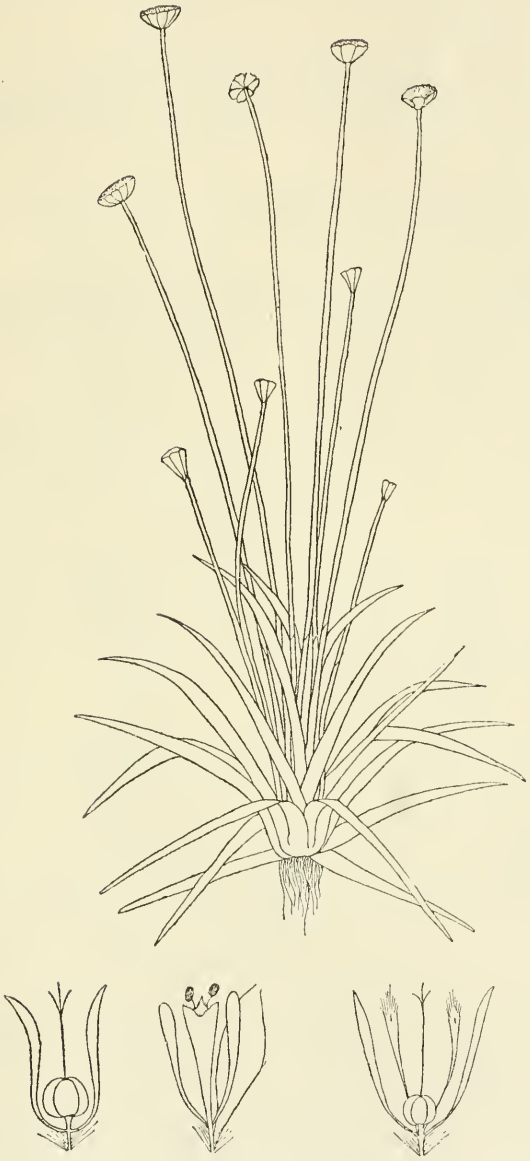
Ceylon; South India on the Pulneys; Anamalais and Nilgiris.



D. R. F. ERIOCAULON THWAITESII *Koern.* (*small plant*)

The plants vary much in size. Those from higher levels on the Pulneys are much smaller than the type, even only 1/2 in. high. They were described by me in Kew Bulletin 1914 as a new species, *E. Mariæ*, and figured in my Flora of the Nilgiri and Pulney Hill tops under that name, since the female sepals are 3 equally boat shaped instead of 2. But I find a plant C. P. 790 in Herb. Calc. the collection quoted by Koerniche Linnaea xxvii p. 627 as in part his type, has the female sepals 3 but unequal, one being flat; and plants from 5,000 ft. on the Pulneys, in no other way distinguishable from what purports to be Koerniches type at Kew, with 3 sepals equal. It seems therefore that this is another instance of the sepals varying within the species, (c. f. *E. truncatum* Ham). At the same time since I do not find them spongey at the back, as described by Koerniche I may be wrong in so identifying these plants.

15. **E. achiton** Koern. (Clarke in Herb. Calc.); F.B.I. vi 584, No. 42; Ruhl. No. 189. A smaller plant than *E. Thwaitesii*. Leaves narrow, almost linear about 1 inch. Scapes twice as long slender.



ERIOCAULON ACHITON. *Koern.*

Heads obconic or hemispheric. Sepals of both sexes 2 only, narrow. Female petals O. Seeds broadly ovate, dark brown, with longitudinal lines. Fig. on p. 203.

Khasia, Eastern Bengal; Bombay, N. Kanara.

The habit and general appearance show this to be probably a derivative of *E. Thwaitesii*; it is therefore put here though there are no petals in the female flower. Koerniche however compared this species with E. *truncatum* Mart. [? Ham.].

16. **E. quinquangulare** L. (Herb. Linn. Prop !); F.B.I. vi 582, No. 36; Ruhl. No. 122.

Stem short or O. Leaves 1-2 in. long, narrowed from the 1/4 in. base flat, usually red. Scapes numerous, 3-5 in. long, slender. Heads 1/5-1/4 in diam., globular or often conical, black gray or white. Involucre light brown, reflexed. Receptacle hairy; flowers normal; sepals flat. Plate 9.

Central Himalaya, Kumaon; Bengal; Chota Nagpur; Central Provinces; and southwards through the Peninsular India on the plains and the Mysore plateau to Ceylon. Not apparently on the higher levels and not in Burma, except Var. *Martiana*.

I have seen Linnæus' own type but not of course dissected it, and the description is taken from sheets in Herb. Calc. and living plants.

Var. b. *Walkeri* Hook. f. F.B.I. vi 583, No. 39; Ruhl. No. 123. Very similar to E. quinquangulare *vera* but differing in the much more hairy receptacle and other parts.

Ceylon.

This should certainly be considered only a variety, for although Hooker in the F.B.I. states it to be a very distinct species, the type sheet in the Ceylon Herbarium is almost, if not exactly, matched by Clarke's No. 20849, collected in Bengal, and intermediates occur.

Var *c. Martiana* Wall. (Wall. Cat. 7279 in Herb. Calc. !); F.B.I. and Ruhl. l.c. under *E. quinquangulare*. Involucral bracts much longer than the floral and extending about 1-1/4 inch beyond the head.

Burma.

Hooker in F.B.I. called this plant a proliferous state of *E. quinquangulare*. But the plant with this number in the Calcutta Herbarium is not proliferous.

17. **E. roseum** Fyson, sp. nov. (Kurz. 232 in Herb. Calc.) Caulis perbrevis. Folia caespitosa 2-8 cm. longa, basi ad apicen contracta, plana, tenuia, in sicco rubescentia. Pedunculi plures, valde tenuia, glabra, 10·25 cm. alta. Capitula 4-6 mm., lata, sed bractae involucrantes demum 2-3 mm. longiores, tenues et reflexae. Bractae flores superantes acutae, nigrescentes. Receptaculum altum, valde villosum. Flores trimeri, flos ♂; sepala in spathan antice fissam connata;



ERIOCAULON ROSEUM. *Fyson.*

petala parva, subequalia ; antherae nigrae. Flos ♀ :—sepala acqualia, nigrescentia ; petala angusta-oblanceolata.

Burma : Pegu, Kurz.

This may be considered a very pronounced stage in the lengthening of the involucral bracts, begun in this series by var. *Martiana* of *E. quinquangulare* and it might perhaps be more properly considered a variety of that species. Its close relationship is shown in the very similar flowers, and the leaves being red or drying red. Of the young heads the involucral bracts are not much longer than the others, they lengthen with age.

18. **E. trilobum** Ham.; F. B. I. vi 583, No. 37 ; Ruhl. No. 88 Habit of *E. quinquangulare* L., but the heads as a rule smaller, 1/8-1/6 in diam., darker, and the involucral bracts more conspicuously reflexed. Leaves not drying red. Plate 10.

N. W. Himalayas ; Kumaon ; Dharmasala ; Bengal, in rice fields (Wallich)

This species exactly resembles *E. Dianae*, var *triloboides* in the Bombay Presidency, except in the reduction in the latter of one female sepal.

I am however uncertain of the identification of the sheets in the Calcutta Herbarium, for Koerniche describes the female sepals as " carinatae, dorso anguste spongioso alatae ", which they are not in these plants, yet there does not appear to be any other plant from Bengal to answer to the rest of the description.

19. **E. collinum** Hook f. (Thwaites enum, 44, C. P. 1000 in Herb. Kew!) ; F. B. I. vi 584 No. 41 ; Ruhl. No. 127. ; Fyson Fl. N. & P. H. T. pp. 430,-1. incl. *E. Christopheri* Fyson and *E. Oliveri* Fyson Stem O or elongate. Leaves 1 1/2-2 1/2 in. by 1/4 in., flat obtuse or if submerged subulate. Scapes many 3-8 in. Sheath about as long as the leaves. Heads 1/4 in., dark, globose. Involucral bracts dark or the outermost or all pale, at length reflexed. Flora dark, obovate cuspidate, sparingly hairy. Receptacle conical. Flowers normal, the sepals dark. Female sepals in Ceylon two boat-shaped, one flat ; in South India all equally boat-shaped. Male petals well developed, slightly unequal.

South India ; on the Nilgiris, Pulneys, Anamalais, etc., at high elevations. Ceylon ; Newara Eliya and Highlands. Flowering in the early part of the summer.

The species varies considerably, possibly in relation only to the environment. The plants are nearly always gregarious, but sometimes in dense clumps, the scapes being numerous and tufted ; sometimes more or less free, the scapes rising each from its own rosette of leaves. The leaves in the type sheet are linear-oblong, about 1 inch by 1/10 inch, with scapes of 7 or 8 times as high, but I find every variation to leaves which may be as much as half as long as the scapes ; they may also taper from a broad base evenly to the tip or be narrow and acicular. They are usually thin or flaccid but may be coriaceous. The heads typically gray with black involucre may be almost white with colourless (pale) involucral bracts. The male petals are not quite equal and in one Pulney plant one male petal of the lowest

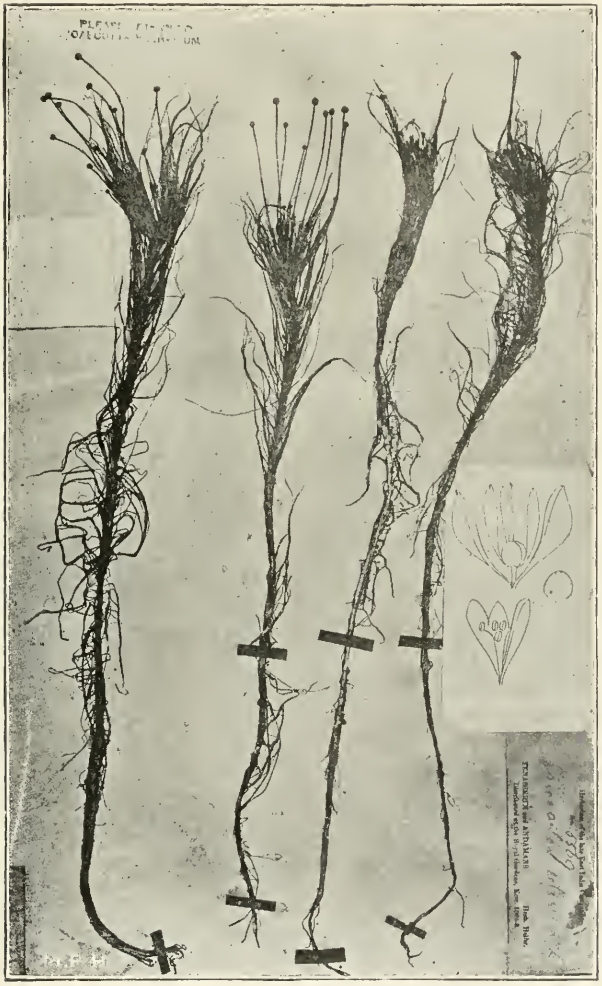
flowers of the head is much large and projects beyond the bracts giving the head a fringed appearance, like that of *E. longicaspis*, but much less pronounced. This feature disappears in dried specimens, but the plant is different in appearing much later on in the year, on bank above the free surface of



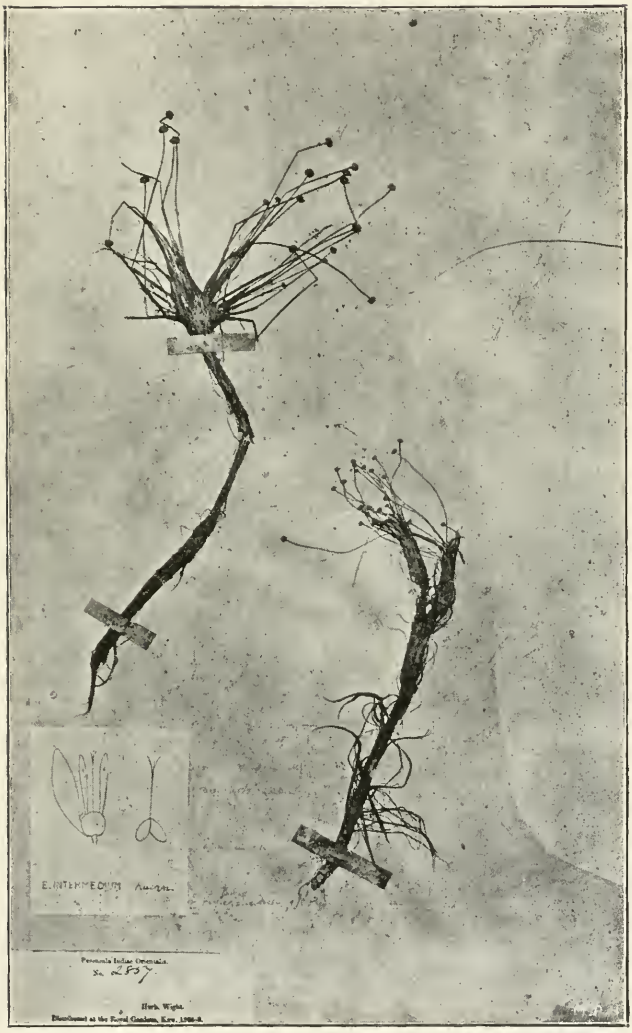
D.R.Fyson ERIOCAULON COLLINUM Hook.

water, not in swamps. In the Flora of the Nilgiris and Pulney Hill tops I separated two forms as new species, but a comparison of a very large number induces me to reduce these again to *E. collinum* Hook. f. with the assumption that the female sepals may vary as between the Ceylon and the S. Indian forms.

(To be Continued.)



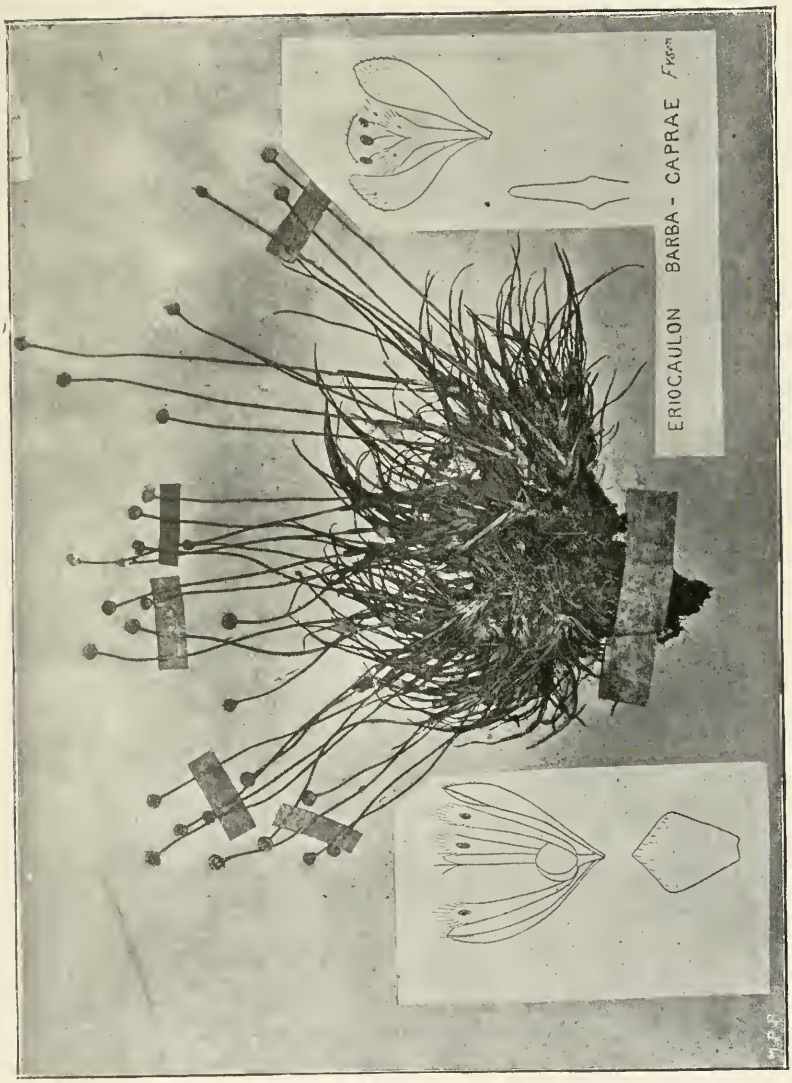
ERIOCAULON SETACEUM *L.*



ERIOCAULON INTERMEDIUM *Kern.*



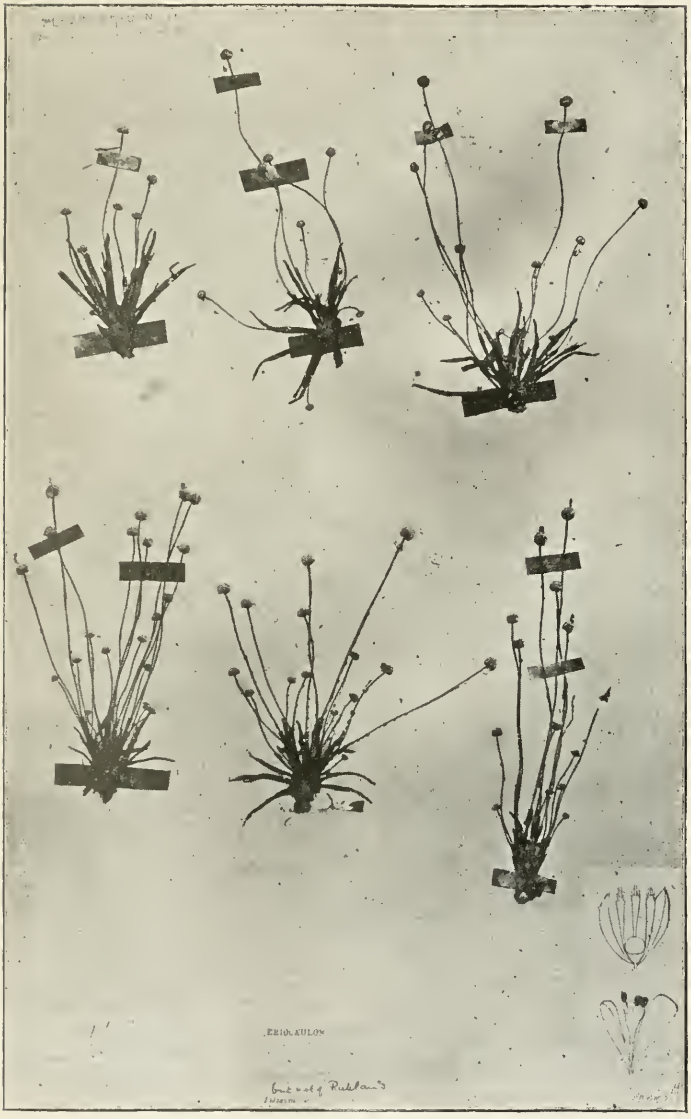
ERIOCAULON COLLETTII *Hook f.*



ERIOCAULON BARBA-CAPRAE *Fyson.*



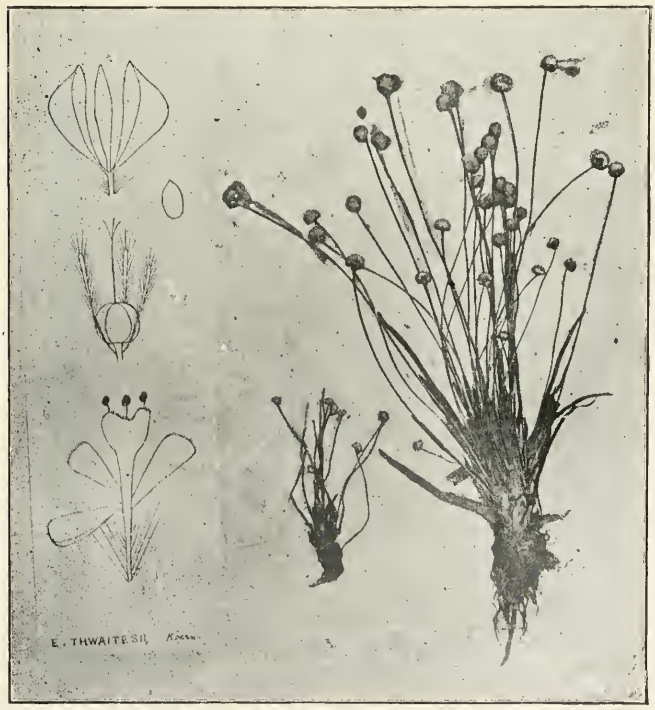
ERIOCAULON GREGATUM *Kœrn.*



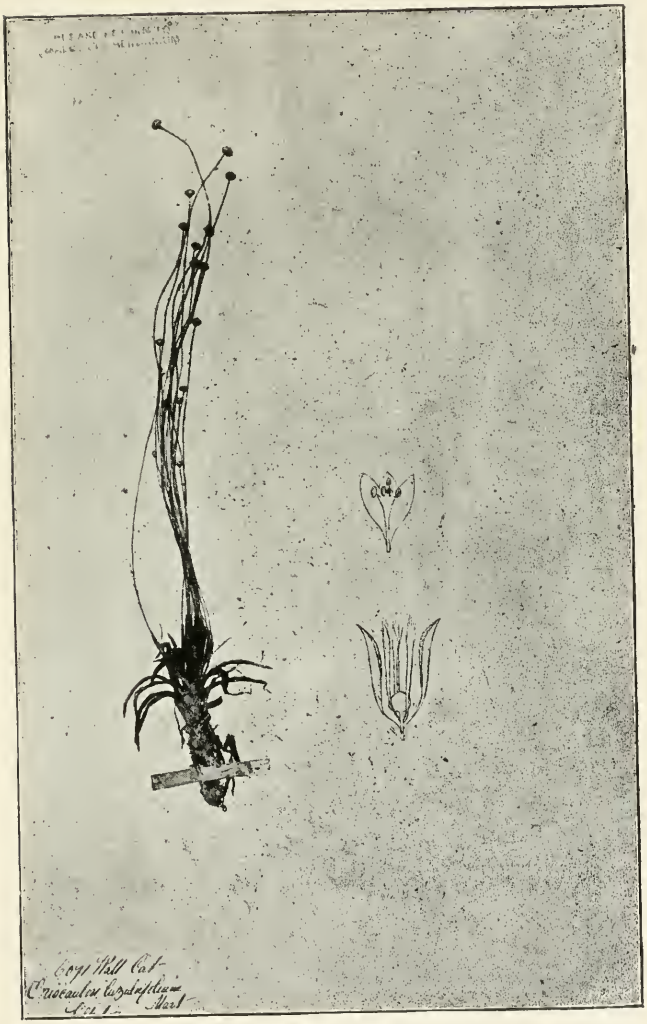
ERIOCAULON NEPALENSE *Prescott.*



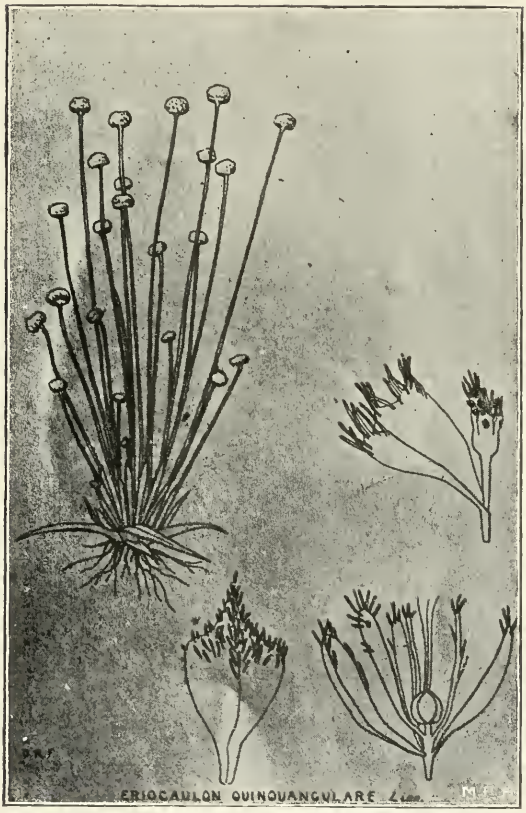
ERIOCAULON PUMILIO *Hook. f.*



ERIOCAULON DUTHIEI *Hook. f.*



ERIOCAULON LUZULAEFOLIUM *Mart.*



D. R. F. del. ERIOCAULON QUINQUANGULARE *L.*



ERIOCAULON TRILOBUM *Ham.*

CURRENT LITERATURE.

New South Indian Species

Indigofera Barberi Gamble sp. nov. Kew. Bull. 5 (1919) page 222, allied to *I. trifoliata* L., and *I. trita* L.f., but differing from the former in the terminal leaflet and torulose legume. Dist. Cuddapah hills, Melpat in South Arcot District, and Shevaroy hills, Salem District.

Erythrina mysorensis Gamble sp. nov. l. c. p. 222, allied to *E. stricta* Roxb., but flowers are smaller with both wings and keels equal and length and the leaves also are different. Dist. Chickenalli, Mysore Province.

Smithia Venkobarowii Gamble sp. nov. l. c. p. 223, allied to *S. blanda* Wall., but flowers not paniculate but subcapitate and calyx glabrous with short ciliate edges. Dist. Travancore hills at Peermade.

Desmodium wynaadense Gamble sp. nov. l. c. p. 223, allied to *D. rufescens* DC., but different from it in having lanceolate acute leaflets, filiform pedicel and legume reticulated. Dist. Nilgiri, Anamalai, and Travancore hills at 2,000 to 5,000 feet.

Vigna Bourneae Gamble sp. nov. l. c. p. 224, allied to *V. pilosa* Baker, but with larger flowers and densely tawny villous leaflets. Dist. Pulney hills—Poombari riverside.

Sonerila pulneyensis Gamble sp. nov. l. c. p. 226, stems creeping and leaves ovate with 3 to 5 slender main veins. Dist. Pulney hills, Pambar ravine.

Memecylon flavescens Gamble sp. nov. l. c. p. 226, large shrub with obovate leaves drying yellow. Dist. Nilgiri, Kundahs, Avalanche and Sisparah.

Memecylon Lawsoni Gamble sp. nov. l. c. p. 226, allied to *M. Heyneana* Benth., but leaves smaller with the intra marginal vein faint, flowers a few only in fascicles and bracteoles ovate. Dist. South-East Wynaad, Nilgiris.

Memecylon Lushingtonii Gamble sp. nov. l. c. p. 227, a very distinct species with slender branches, leaves drying green and flowers with short pedicels. Dist. Cuddapah hills, Nilgiris and Osahatti (Coimbatore District).

Memecylon madgolense Gamble sp. nov. l. c. p. 227, closely allied to *M. marginata*, Bl., but differing in leaves being smaller and pedicels shorter. Dist. Madgol hills of Vizagapatam.

Memecylon sisparense Gamble sp. nov. l. c. 227, allied to *M. malabarica* Cogn., but leaves short petioled and slightly cordate at base. Dist. Nilgiris Sisparah.

Pimpinella pulneyensis Gamble sp. nov. l. c. 228, allied to *P. Leschenaultii DC.*, but the basal leaves with broader sinus, longer petioles and with 10 to 20 nerves. Dist. Pulney hills—Kodaikanal. Fyson Pl. Nilg. and Pul. Hill tops, t. 128.

Schefflera Bourdillonii Gamble sp. nov. l. c. p. 228, leaflets obovate and the inflorescences are compact stellate-villous umbels. Dist. Travancore near Chimunjee.

Osbeckia travancorica Bedd. MSS. and Gamble sp. nov. Kew. Bull. 10 (1919) p. 404, allied to *O. Wightiana* Benth., easily known by the long retrorse bristles on the stem and the lanceolate acuminate leaves. Dist. Travancore, Mundakayam and Peermade.

Oldenlandia Bourdillonii Gamble sp. nov. l c., allied to *O. stylosa* O. Kze., but differing from it in having multidentate stipules and membranous lanceolate leaves. Dist. Travancore.

Oldenlandia eualata Gamble sp. nov. l. c., allied to *O. swertivides* O. Kze., but with long petioled leaves and clearly paniculate inflorescence. Dist, Nilgiris, Pykara and hills of South Tinnevelly.

Oldenlandia Ramarowii Gamble sp. nov. l. c. p. 405, allied to *O. membranacea*, O. Kze., but with scabrid hairs on the conspicuous nerves of the leaves and with pedicels different. Dist. Travancore, Ponmudi.

Oldenlandia villostipulata Gamble sp. nov. l. c. p. 405. A distinct species with axillary cymes, slender pedicels and with villous multifid pectinate stipules. Dist. Travancore, Mutthukulivayal.

Oldenlandia wynaadensis Gamble sp. nov. l. c. p. 405, allied to *Oldenlandia* (*Hedyotis*) *sisparensis* Gage, but with smaller leaves, villous, pectinate, triangular stipules and with short, secund, cymes. Dist. Wynaad.

Oldenlandia anamalayana Gamble sp. nov. l. c. p. 2 (1920) p. 67, allied to *O. Lessertiana* O. Kze., but with plicate leaves and umbellately disposed cymose inflorescence with small flowers and slender pedicels. Dist. Anamalai hills.

Oldenlandia Barberi Gamble sp. nov. l. c. 68. A distinict species with sessile axillary cymes and with non-pectinate stipules. Dist. Tinnevelly Agastiyarmalai peak.

Ophiorrhiza Barberi Gamble sp. nov. l. c. p. 406, allied to *O. Brunonis* W. & A., but differing from it in the bracts and the cymes. Dist. Anamalai hills : Paralai, Travancore hills : Mankulam.

Ophiorrhiza codyensis Gamble sp. nov. l. c. p. 406, allied to *O. pectinata* Arn., but with persistent ovate lateral stipules and distinct cymose inflorescence. Dist. Coorg : Sampagi ghat.

Ophiorrhiza pykarensis Gamble sp. nov. l. c. p. 407. A very distinct species with minute bracteoles and few flowered cymes. Dist. Nilgiris : Pykara Falls.

Knoxia linearis Gamble sp. nov. l. c. p. 68, allied to *K. Wightiana* Wall., but differing in having pubescent somewhat linear lanceolate leaves and pubescent elongate stipules. Dist. Tinnevelly Dt. Mahendragiri hills.

Ixora monticola Gamble sp. nov. l. c. p. No. 7. (1920) p. 246. A distinct species with small leaves and sessile cymes. Dist. Madura Dt. Cumbum.

Ixora Lawsoni Gamble sp. nov. l.c. p. 247. A distinct species with ciliate linear calyx lobes with corymbose cymes. Dist. Coorg and Wynaad : Manantoddy.

Ixora Saulieri Gamble sp. nov. l. c. p. 247, allied to *I. Lawsoni* Gamble, but with short sparsely hairy caylx lobes, filiform bracts and different inflorescennce. Dist. Madura Dt. Pulney hills.

Coffea crassifolia Gamble sp. nov. l. c. sp. 248, allied to *C Khasiana* Hook. f., but with larger leaves and ellipsoidal fruits. Dist. Anamalai hills, Ayerpadi, Travancore, Peermade.

Morinda reticulata Gamble sp. nov. l. c. p. 248, allied to *M. umbellata* L., but with thick calyx lobes and glabrous coriaceous leaves with a different reticulation. Dist. Travancore : Kulathurpolay.

Psychotria Barberi Gamble sp. nov. l. c. p. 248. A species with membranous long-petioled leaves and with quadrisulcate pyrenes. Dist. Coimbatore Dt. Anamalai hills, Travancore Munaar.

Psychotria globicephala Gamble sp. nov. l. c. p. 249, allied to *P. Thwaitesii* Hook. f., but with flowers in globose heads, calyx lobes ciliate and obovate and leaves with faint nerves. Dist. Tinnevelly hills : Courtallam.

Lasianthus cinereus Gamble sp. nov. l. c. p. 249, allied to *L. dichotomo* Wight., but differing in the nervation of the leaves and with short peduncles. Dist. Tinnevelly : Kalivayalpil and Naterikal.

Centratherum Rangacharii Gamble sp. nov. l. c. 10 (1920) p. 338, allied to *C. molli* Benth., and *C. courtallensis* Benth., but with smaller heads and different in leaves and achenes. Dist. Tinnevelly, Mahendragiri, Naterikal and Kalivayalpil.

Vernonia anamallica Beddome MSS. and Gamble sp. nov. l. c. p. 339. A distinct species with yellow tomentose leaves and glabrous pentagonal achenes. Dist. Anamalai hills.

Vernonia Bourdillonii Gamble sp. nov. l. c. p. 339, allied to *V. Wightiana* Arn., and *V. Ramaswamii* Hutch., but leaves are smaller and corymbs few flowered. Dist. Travancore : Ponmudi and Chimunjee.

Vernonia gossypina Gamble sp. nov. l.c. p. 340, allied to *V. salvifolia* Wight, but with trigonous glandular achenes and very softly thickly tomentose leaves. Dist. Tinnevelly, Sengalteri to Naterikal.

Vernonia Heynei Bedd. MSS. and Gamble sp. nov. l. c. p. 340, allied to *V. indica* : C. B. Clark., and V. Fysoni Calder., Dist. Travancore.

Vernoina multibracteata Gamble sp. nov, l. c. p. 340, allied to V. *Salvifolia* Wight. Dist. Travancore : Peermade.

Vernonia pulneyensis Gamble sp. nov. l. c. p. 341, allied to V. *pectiniformis* DC., but leaves are distinctly serrate, corymbs short peduncled and few flowered. Dist. Pulney hills, Kodaikanal near Pambar river. Fyson Fl. Nilg. and Pul. Hill tops t. 377.

Vernonia shevaroyensis Gamble sp. nov. l. c. p. 341, allied to V. *volkamerifolia* DC., but with leaves differently hairy and with heads having single florets. Dist. Salem Dt. Shevaroy hills.

Helichrysum perlanigerum Gamble sp. nov. l. c. p. 341, allied to *H. Wightii* C. B. Clarke, but with cinnamomeous tomentum all over the plant and with differences in the involucral bracts. Dist. Anamalai hills.

Senecio Lawsoni Gamble sp. nov. l. c. p. 342, allied to *S. lavandulaefolius* DC., but with small leaves uniformly borne by the stem, few flowered corymbs and many nerved ligules. Dist. Nilgiris : Avalanche to Sisparah.

Physiology

Beckley, V. A. The preparation and fractionation of Humic acid ; and the formation of Humus. *Jour. Agric. Science*, XI, 1st January, 1921, pp. 66 & 69.

In the first of these papers the author describes experiments which go to show that humic acid obtained by ashing the humus obtained from an alkaline extract of soil by an acid or by boiling sugar with acid is a mixture of two acids, separable by pyridine ; one probably tri-basic and the other terra-basic ; and not one body as previously supposed.

In the second he shows that carbohydrates when acted on by acids, whether mineral or amino, produce hydroxymethyl-furfural, (a ring compound consisting of an oxygen atom linked to 4 carbons, to which are attached CH_2OH ; CH ; and CHO respectively) and that this condenses to humus. This is the process whether the action takes place in the laboratory or the field, and whether from sugar, celluluse or straw. No evidence could be obtained that hydroxymethyl-furfural was produced during the decomposition of cellulose by Spirochæta cytophaga.

P. F. F.

Harrison, W. H. Carbon dioxide in relation to rice soils. *Memoirs of the Department of Agriculture in India.* Chemical Series V. 8th November, 1920.

In a previous paper the author and Subramanya Aiyar showed that the gasses of paddy soil are mainly methane and nitrogen, while carbon-dioxide and hydrogen occur only in small quantities. But in ordinary decomposition of organic matter under anerobic conditions, such as presumably obtain in paddy soil, the opposite is the case, there is little nitrogen and much hydrogen and carbon-dioxide. From the experiments described in this paper the author concludes that this difference is due not to the fermentation being of a different type, but to secondary chemical changes where by the hydrogen and carbon-dioxide produced combine to form organic matter and methane. The result of this is that there is less hydrogen available to absorbe oxygen, thus increasing the amount of the latter available for æration of the roots. Another advantage to the plant is the removal of the carbon-dioxide. The methane is also of use since it increases the oxygen supply by the action of the surface film, as shown in a previous paper. The organic matter so formed will also be decomposed in like manner, with fresh evolution of methane and nitrogen. In this way comparatively large quantities of nitrogen are set free, and there is no need to postulate the action of specific bacteria.

P. F. F.

Plant disease

Blakeslee, A. F. A graft infectious disease resembling a vegetative mutation. *Jour. of Gentics II. 1st April, 1921.*

In this paper is described a disease of Datura stramonium which causes profound changes in leaf, flower and fruit. The leaves become narower and incised, the corolla is split down to the base and frequently fails to become free of the calyx, the stamens are devoid of pollen, the capsules are less spiny or quite smooth, and the colour of the plant is usually darker. The disease appears in the field to the extent of about 1·6 % of all the plants, but up to 26% in an experimental plot where the plants were more widely spaced. This the author thinks was due to the plants growing larger and therefore having a larger area liable to infection. It is transmitted by seed produced by healthy pollen to the extent of about 79%, the remaining 21% of plants raised from diseased stock being entirely free from it. It is transmitted by pollen, that is when pollen is used from normal or nearly normal flowers of plants that are beginning to show the disease, and lastly it is transmitted by grafting: a diseased branch used as scion will affect a healthy stock and even a healthy scion grafted on to the same healthy stock.

It is suggested that vegetative segration and mosaic inheritance in other plants may sometimes be due to some such disease. To the writer of this abstract it appears possible that this disease is similar to the spike-disease of Sandal and other plants in this country, which so far have been studied only on the physiological side, not as far as he knows genetically.

P. F. F.

Plant-breeding, Heredity, etc.

Bateson, W. Root-cuttings and chimaeras II *Jour. of Genetics. II., 1st April, 1921.*

The author continues his investigation into the product of root-cuttings of certain variegated cultivated plants, of Bouvardia, Pelargonium, and Spiraea ulmaria. In these plants there appears to be a core of one kind overlaid by a cortex of another, the latter giving the varietal character of the plant. Many such herbaceous plants are liable to give rise by root-cuttings to shoots composed entirely of either their external or their internal constituent. Such shoots are probably formed by adventitious buds, which clearly are not always endogenous, but may arise from the cortical layer. The instance of a core character appearing in patches on a leaf are difficult to explain, the growing point apparently has both elements in it.

Refering to " reversal," described in Vol. IV (see this journal Vol. I, p. 63) while several instances have been seen of white-over-green turning to green-over-white, none have been found of the oposite.

P. F. F.

Rangaswami Aiyangar, G. N. Some rice breeding experiences. *Agri. Jour. India, XVI, 2nd March, 1921.*

The author who has been for several years engaged in breeding varieties of rice with, F. R. Parnell, gives here some of his experiences and much sound

advice to those who contemplate such work. He writes as an enthusiast, and no one not an enthusuiast could stand the exhausting work of standing for hours in a paddy swamp and in the blazing sun. But probably Mr. Rangaswami would rather say, that no one who has experienced the engrossing interest of such work could fail to become an enthusiast. He touches on practically every process, sowing, transplanting. labelling, roguing, and the storing of the seed, and the paper should be read by all who take up this very useful and interesting line of work.

P. F. F.

Books

The Flora of the Nilgiri and Pulney Hill tops,—being the commoner wild and introduced flowering plants of the hill-stations of Ootacamund, Kodaikanal and Kotagiri, Vol. III including the country round Coonoor and down to 5,000 ft. By P. F. Fyson, with illustrations by Mrs. Fyson and others. *Madras, at the Government Press, Rs. 15/6.*

This volume is supplementary to the two which appeared in 1915 and dealt with the plateau down to 6,500 ft. It contains not only the species of the wider area but illustrations of many of those described before but not figured. It is however not merely a supplement, for the Natural Orders and most of the genera and species are given again with reference to the page or figure in the other volumes. The first volume was not by any means a compilation of previously published work; it was based on the author's own collections, supplemented by those of Sir Alfred Bourne, and others, and was conspicuous for evidence of real research, the correctness of the naming being authenticated by reference in most cases to the actual type sheets of the species. The present volume which has been produced in India is necessarily without these references. Another difference is in the absence of the short notes on the origin of the names or the natural history of the species which added so much to the interest of the first volume. It contains a few corrections of errors, as Vernonia Bourneana for V. cormorinensis; and changes of name, in which the author has taken advantage of the published parts of Gamble's Flora of the Madras Presidency. Chief of these that we notice are Schefflera for Heptapleuron, Centella asiatica for Hydrocotyle as., Korthasella japonica for Viscum Jap., and Asparagus Fysoni for A. subulatus; and in a note on botanical nomenclature the author explains the reasons for changes of this sort, a note which will be appreciated by those to whom such changes might otherwise appear unnecessary and irritating.

Of the 296 full page illustrations most are by the author's wife and are remarkably natural and true to the fresh plant. Among much that is good we would specially point to her Compositae and Loranthaceae, and to the author's Gramineae and Cyperaceae, in all of which the dissections are also good.

The printing of the letter press is up to the high Standard of Vol. I, and though the lines of the figures are sometimes a little thick, this is perhaps due to the stout paper on which they are printed. But the book has suffered from the author's inability to see it through the press, there being several misprints in the latter half, and several of the illustrations being upside down

or with the title on the wrong margin. There are also errors in the plates which a more careful revision as they were being printed would have disclosed. We think too that it would have made the volume more useful if every species of Vol. I had been at least mentioned again, and not only those which required a note. The index might then have contained reference to Vol. I direct, instead of being confined to the pages of the present volume and plates in II. But while we point out these imperfections, which may no doubt justly be put down in part at least to the author's ill-health, we have only praise for the book as a whole and for the author's zeal in producing such a work in his spare time. It contains much that is of scientific value, with original notes on the natural history or habit of the species never before made known, and by making the identification of these plants easy should render possible a further and fuller study of the ecology of this area. To the many real flower-lovers among the residents and visitors of these hill-stations this third volume will give, as we know the other two have given, much real pleasure and they especially will be grateful to Mrs. Fyson for the labour of love involved in drawing her 250 plates.

Printed and Published for the Proprietor by W. L. KING at the Methodist Publishing House, Mount Road, Madras.

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It would greatly assist the Honorary Editor if the following rules are kept in mind by Contributors :—

All matter for the printer should be typed and on one side of the paper only. The name of a genus should begin with a capital letter, but that of the species only when it is adapted from a proper name. No comma should be put in after the specific name and before that of the founder of the species. The Editor will see to the type.

Illustrations in line should be drawn in India ink on smooth paper or card, and will reproduce best if at least twice as large as they will appear in the Journal. Photographs for reproduction by half-tone process must be on glossy paper and should be strong bright prints. Good results cannot be obtained from over-exposed negatives or weak prints.

Abstracts of papers in other Journals should begin with the author's name and initial, followed by the title of his paper and where it is published: the abstract itself beginning a new line.

Twenty-five reprints of original papers will be supplied free and more may be had on payment if asked for at the time the contribution is sent in.

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Vol. II. Nos. 8 & 9

The Journal of Indian Botany

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THE

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VOL. II. SEPTEMBER, 1921. NOS. 8 & 9.

THE PHYSIOLOGICAL ANATOMY OF THE PLANTS OF THE INDIAN DESERT

BY

T. S. SABNIS, B.A., M.Sc.,

St. Xavier's College, Bombay.

(*Continued from p. 167*).

CYPERACEAE—(*Contd.*)

Scirpus maritimus *L.*—Figs. 311, 312, 313, 314, 315, 316, 317. Margins pointed and protected by stereome bundles. Stomata on both the surfaces of the leaf-blade with the front cavity depressed. Stomata on the leaf-sheaths on the outer side only. Mesophyll in the leaf-blade wholly of palisade cells on either side of stereome girders. Lysigenous cavities alternating with the veins in the leaf-blade and leaf-sheath. Veins in the leaf-blade vertically transcurrent above and below by aqueous cells. Articulation tissue not developed except for aqueous cells on either side of the veins. Mechanical tissue in the leaf-blade forming I-girders, webs being formed by unmixed vascular bundles; and that in the leaf-sheath in the form of isolated sub-epidermal girders on the outer side above the veins. Veins enclosed in an outer ring of large polygonal colourless cells and of an inner ring of stone-cells. T. S. of the axis triangular. Assimilatory tissue in the axis of palisade cells between stereome girders. Vascular bundles enclosed in rings of stereome. Peripheral bundles apposed to the stereome girders. Mechanical tissue in the form of isolated sub-epidermal girders, those at the angles forming composite large strands. Ground tissue not differentiated in the centre into pith and of cells with granular contents.

Structure of the leaf.—The epidermis consists of cells with outer walls flat, greatly thickened and silicified. Inner walls are angular and fit into the sub-epidermal tissue so as to form a com-

pact structure. Lateral walls are thin and straight. The upper epidermis forms the aqueous articulation tissue and is many-layered in species of *Cyperus*. The articulation tissue in the mid-rib of *C. rotundus* (fig. 303) and *S. maritimus* consists of elongated cells narrowed above so as to form a specialised articulation tissue to regulate the upward curving movements of the leaf-halves by the difference in the turgidity of these cells. As these cells are greatly narrowed in their upper portion, the leaf-halves can come quite close together and thus protect the articulation tissue from suffering much loss of water in times of very dry weather. Such a tissue in the mid-rib is not necessary in other species of *Cyperus*, as there is abundant aqueous tissue and as the leaf-halves are very short. In *F. tenera* the articulation is 2-3-layered in the mid-rib.

Margins are rounded in *C. rotundus* or are bluntly pointed as in other species of *Cyperus* and in *S. maritimus* or peculiarly angular in *F. tenera* (fig. 308).

Stomata in species of *Cyperus* and in *F. tenera* occur only on the lower surface of the leaf; in *S. maritimus* they are more numerous on the lower surface. The occurrence of stomata only on the lower surface is due to the presence of the assimilatory tissue below the lower epidermis; their presence on the upper surface, where the articulation tissue is developed, will accelarate transpiration and will thus perform a function opposite to that of the articulation tissue. The occurrence of stomata on both the surfaces in *S. maritimus* is partly due to the absence of aqueous tissue near the surface and partly to the presence of photosynthetic tissue along both the surfaces. The guard-cells are elevated and are accompanied by subsidiary cells in all the members. The front cavity is placed on a level with the surface in *C. rotundus*, while in other species of *Cyperus* and in *S. maritimus* it is placed in a depression formed by outer thickened epidermal walls; in *F. tenera* it is elevated above the surface.

The stomata on the leaf as well as those on the axis of all members have on obconical sub-stomatal cavity which is lined by elongated cells forming an obconical tissue. The obconical cavities are quite conspicuous in *C. conglomeratus* (figs. 299, 303, 302) and also occur below the epidermis even where stomate do not occur. The obconical shape of sub-stomatal cavities and also that of the sub-stomatal tissue forms a characteristic feature of members of *Cyperaceae*. Stomata occur on the outer surface of the leaf-sheath of *S. maritimus*. Stomata on the leaf-sheath as well as those on the axis like those on the leaf.

The photosynthetic tissue in species of *Cyperus* and in *F. tenera* is composed of complete girders of tubular palisade cells round all the

veins except the vertically transcurrent ones in *C. niveus*, where it forms arcs of palisade cells on the sides of the veins (fig. 298). In the leaf-blade of *S. maritimus* tubular palisade cells form groups below the epidermis, the adjacent groups being separated by a tissue of loosely arranged arm-palisade cells which are afterwards destroyed to form cavities alternating with the veins. In *C. rotundus* there is a tissue of thin-walled parenchymatous cells occurring below and between the veins and similarly forming cavities below the stomata. Cells above the zone of the palisade tissue in species of *Cyperus* and those on either side of the veins in *S. maritimus* form the aqueous articulation tissue with a two-fold function, that of collecting water and that of regulating the upwards curving movements of the leaf-halves. The abundance of the aqueous articulation tissue in species of *Cyperus* can be accounted for by the abundance of veins. In *F. tenera* leaf-blades are thin and the veins together with their girders of palisade cells and a few secretory cells occupy the whole space between the epidermis on either side.

In the leaf-sheaths of *S. maritimus* palisade cells form small groups on the sides of the isolated sub-epidermal girders. The veins, except those at the angular portions, are separated by a tissue of stellate cells which, later on, are destroyed and cavities are formed. The occurence of these lysigenous cavities in abundance is the result of the water-supply being insufficient to maintain all the tissues in a fully developed leaf-blade. The thin-walled parenchymatous cells do not form any important tissue; they, therefore, lose their turgidity, shrivel up and are destroyed to form cavities.

Internal glands are represented by numerous secretory cells with tanniniferous contents near the veins in the leaf-blades and leaf-sheaths and in neighbourhood of vascular bundles in the axis. A few secretory cells occur in the ground tissue of the axis.

Veins are numerous and are confined to the lower half of the mesophyll except in *F. tenera* and *S. maritimus*, in which they are placed in the middle of the mesophyll. Larger veins usually alternate with smaller ones and when veins occur in two planes those in one plane alternate with those in the other (fig. 300). This gives rigidity to the leaf-blade and accommodates a larger number of veins in a small space of the lower half of mesophyll. In species of *Cyperus* and in *F. tenera* smaller veins are enclosed in two rings, the outer one of stereome and the inner one of green sheath-cells. Larger veins are enclosed in a single outer ring of stereome and the inner ring is represented by two arcs of sheath-cells. Some of the larger veins in *C. nivens* are vertically transcurrent above and below by stereome bundles (fig. 298). In *F. tenera* a single large vein occurs in the

angular margin and is supported by angular stereome bundles ; other veins are small and are placed in the middle of the mesophyll.

In the leaf-blade and leaf-sheath of *S. maritimus* veins are enclosed in an outer ring of stereome and in an inner ring of large colourless polygonal cells. All the veins are vertically transcurrent ; those in the leaf-blade are vertically transcurrent above and below by aqueous cells and those in the leaf-sheath are apposed to lower epidermis and are vertically transcurrent above by aqueous cells.

The mechanical tissue in *C. rotundus* (figs. 303, 304) and in *C. niveus* (fig. 298) is composed of isolated sub-epidermal girders, which are more numerous on the lower surface. On the lower surface the subepidermal girders are found above the veins and on the upper surface they occur at regular intervals, being developed more or less above every alternate vein in *C. rotundus*. In *C. niveus* there are some I-girders in association with the larger veins, webs of which are formed by unmixed vascular bundles. In *C. conglomeratus* and in *C. arenarius* isolated sub-epidermal girders occur only on the lower surface above the lower veins ; and there is a long sub-epidermal girder on the upper surface near one margin (fig. 300). The mechanical tissue in *F. tenera* is represented by sub-epidermal girders in the angular margins and below the mid-rib which is greatly projected downwards. The mechanical tissue in leaf-blades of *S. maritimus* (fig. 312) consists of I-sub-epidermal girders webs of which are formed by mixed vascular bundles of the veins and of small sub-epidermal girders in the margin and on the lower surface of the mid-rib. The sub-epidermal girders in leaf-sheaths occur on the outer surface above the veins and at the angles.

The occurrence of extensive mechanical tissue on the lower surface protects the lower surface against tension produced in the upwards-curving movement of the leaf-halves which are brought about by diminution in turgidity of the cells in the articulation tissue in the upper half of the leaf-blade.

Hairs, either clothing or glandular, are absent in all the members.

Structure of the axis.—The epidermis consists of tabular cells with outer walls flat, greatly thickened and silicified. Inner walls are very thin and angular and lateral walls are thin and straight. Epidermal cells between the girders in species of *Scirpus* are uniformly sclerosed.

The assimilatory tissue in species of *Cyperus* and in *F. tenera* is composed of girders and arcs of tabular palisade cells round smaller veins and on sides of the upper portion of larger veins respectively. In *S. quinquefarius* (figs. 309, 310) palisade tissue occurs between and below the girders, while in *S. maritimus* (fig. 315) it occurs between the girders.

The vascular system consists of numerous peripheral bundles seated on sub-epidermal stereome girders in all members except *S. quinquefarius* and of a few inner bundles embeded in the ground tissue. Peripheral bundles are of two sizes, larger ones alternating with the smaller. Smaller bundles in species of *Cyperus* in *F. tenera* and in *S. maritimus* are enclosed in an outer ring of stone-cells and in an inner ring of green sheath-cells; larger bundles are enclosed in a single ring of stone-cells which is many layered on the inner side. In *C. arenarius*, besides the peripheral bundles seated on the girders there are other small bundles not protected by any sub-epidermal girders and alternating with the former. Smaller bundles in *S. quinquefarius* (fig. 310) occur in the assimilatory tissue and are not apposed to the sub-epidermal girders; the larger ones are placed in ground tissue strands.

The ground tissue consists of thin-walled parenchymatous cells and is traversed in its outer portion by vascular bundles; it is not differentiated in the centre into pith except in *C. rotundus* in which the central tissue is composed of a few larger thin-walled cells. The ground tissue in *S. quinquefarius* is represented by one-layered plates of parenchymatous cells enclosing large air-spaces. Vascular bundles occur in the traversing plates. The occurrence of sclerenchyma in the ground tissue of *S. quinquefarius* is the result of its being found on wet ground.

General Review.—Epidermal cells have outer walls greatly thickened and silicified. Inner walls are angular and lateral walls are straight. The upper epidermis is modified to form the aritculation tissue in species of *Cyperus* and in *F. tenera*. Stomata occur only on the lower surface in species of *Cyperus* and in *F. tenera* where the upper epidermis forms the articulation tissue; they are found on both the surface in *S. maritamus* in which the epidermis on either side is not modified into the articulation tissue. The guard-cells are elevated and are accompanied by subsidiary cells. The front cavity is either placed in a depression formed by the outer thickened epidermal walls or it is elevated above the surface. Stomata on the leaf as well as those on the axis are characterised by obconical cavities around which are also developed obconical groups of elongated obliquely placed cells. The photosynthetic tissue in the leaf and axis consists of tabular palisade cells. Veins are numerous and are arranged in a single row or in two rows larger veins alternating with the smaller. Smaller veins and vascular bundles in the axis in species of *Cyperus* and in *F. tenera* are enclosed in an outer ring of stereome and in an inner ring of sheath-cells; larger veins are enclosed

in a single ring of stone-cells. In *S. maritimus* veins as well as the vascular bundles in the axis are enclosed in an outer ring of large colourless polygonal cells and in an inner ring of stereome.

The mesophyll in *C. rotundus* and in *S. maritimus* is characterised by a system of lysigenously formed cavities resulting from a deficient supply of water. Internal secretory cells with tanniniferous contents are numerous near the veins in the leaf and in the neighbourhood of vascular bundles in the axis. The mechanical tissue in the leaf as well as in the axis is mostly composed of isolated sub-epidermal girders except in the leaves of *S. maritimus* in which I-girders are found. Vascular bundles in the axis are numerous and peripheral, larger bundles alternating with the smaller.

The ground tissue is composed of thin-walled parenchymatous cells with a differentiated central tissue of much larger cells in *C. rotundus*. The ground tissue in *S. quinquefarius* is characterised by large air spaces. *S. quinquefarius* occurs always on wet ground and well developed aerenchyma is consequently quite necessary.

The axes of *S. maritamus* are enclosed in close fitting leaf-sheaths which protect the axes against insolation and also give, to some extent, rigidity to the axes against the violence of the desert winds. Leaf-blades which are as long as the axis are held in position by means of leaf-sheaths and cannot therefore be easily separated from the axis by the strong desert winds. The long leaf-blades, but for the leaf-sheaths, would have been torn off from their bases by the desert winds.

Hairs either clothing or glandular are not found on the leaf and axis.

GRAMINEAE

Digitaria sanguinalis *Scop.* **var. ciliaris** *Prain.*— Grooved on the lower surface. Hairs spiny on the leaf and absent on the axis. Stomata more numerous on the lower surface. Articulation tissue not extensive and found on the upper side above the grooves. Palisade cells forming complete girders. Veins embedded and enclosed in complete sheaths. Mechanical tissue in the leaf in the form of I-girders. Webs formed by unmixed vascular bundles. Mechanical tissue in the axis forming isolated sub-epidermal girders and an internal stereome tube. Assimilatory tissue absent in the axis. Smaller bundles embedded in the stereome tube. Large bundles few in the medullary tissue. Medullary tissue of thin-walled cells.

Panicum turgidum *Forsk.* — Figs. 319, 320, 321. Equally deeply grooved on both sides. Margins blunt and with large stereome bundles. Hairs spiny and absent on the axis. Stomata more

numerous on the upper surface. Articulation tissue extending between two surfaces. Veins few, embedded and with complete sheaths. Palisade cells forming complete girders. Mechanical tissue forming I-girders in association with all the veins. Mechanical tissue in the axis forming stereome tube supplimented by I-girders. Webs formed by mixed vascular bundles. Assimilatory tissue in the axis formed of palisade cells and with a continuous layer of sheath-cells on its inner side. Smaller vascular bundles forming webs of I-girders. Larger vascular bundles in the medullary tissue. Medullary tissue of thin-walled cells.

Panicum antidotale *Retz.*—Fig. 322. Leaf deeply but unequally grooved on two surfaces. Hairs spiny and absent on the axis. Stomata more numerous on the lower surface. Rows of articulation tissue cells not as conspicuous as in *P. turgidum*. Veins numerous. Palisade cells forming complete girders round the veins. Mechanical tissue in the form of I-girders in association with larger veins. Veins embedded and provided with complete sheaths. Assimilatory tissue in the axis formed of chlorenchyma. Mechanical tissue in the axis formed by stereome tube supplemented by sub-epidermal I-girders. Webs formed by unmixed vascular bundles. Some of the smaller vascular bundles embedded in the assimilatory tissue. Smaller vascular bundles provided with arcs or complete girders of sheath-cells. Some of the larger bundles embedded in the stereome tube. Larger bundles numerous in the medullary tissue Medullary tissue of thin-walled cells.

Cenchrus catharticus *Del.*—Figs. 323, 324. Leaves deeply grooved on the upper surface. Epidermal cells vertically elongated. Margins blunt and with large stereome bundles. Stomata more numerous on the lower surface. Hairs spiny and absent on the axis. Articulation tissue extending between two surfaces. Veins provided with complete sheaths. Larger veins vertically transcurrent above and below by aqueous cells and sub-epidermal stereome girders. Larger veins placed in a higher plane and situated below the ridges. Mechanical tissue in the leaf in the form of isolated sub-epidermal girders on the lower side of the veins in furrows and on both the sides of the veins in the ridges forming I-girders. Webs formed by mixed bundles. T. S. of the axis horn-shaped. Assimilatory tissue forming strands of chlorenchyma between smaller bundles. Mechanical tissue in the axis forming a stereome tube supplimented by I-girders. Webs formed by unmixed small bundles. Smaller bundles forming webs of I-girders. Of the larger bundles some embedded in the stereome tube and some in the medullary tissue. Medullary tissue of thin-walled cells.

Latipes senegalensis *Kunth.*—Fig. 325. Deeply grooved on the upper surface. Margins pointed and with small stereome bundles. Hairs spiny and absent on the axes. Stomata more numerous on the upper surface. Articulation tissue in the upper portion of the mesophyll. Veins provided with horse-shoe shaped sheaths incomplete below. Veins vertically transcurrent. Mechanical tissue in the leaf in the form of I-girders. Assimilatory tissue absent in the axis. Mechanical tissue in the form of subepidermal stereome tube. Small bundles embedded in stereome tube. Large bundles few in the medullary tissue. Medullary tissue of very thick-walled cells filled with granular contents.

Elionurus Royleanus *Nees.*—Figs. 326, 327. Epidermal cells on the upper surface vertically elongated and papillose. Surface not grooved. Hairs unicellular, long and only on the upper surface. Margins blunt and with small stereome bundles. Epidermal cells forming articulation cells. Epidermal cells on the lower surface tabular and with angular thickenings on outer walls. Stomata only on the upper surface. Palisade cells forming complete girders round smaller veins. Veins provided with sheaths. Upper cells of sheaths of vertically transcurrent veins forming aqueous cells. Larger veins apposed to epidermis above and vertically transcurrent below by stereome. Mechanical tissue in the leaf in the form of isolated sub-epidermal girders on the lower side of some of the larger veins. Assimilatory tissue absent in the axis. Mechanical tissue in the axis forming a sub-epidermal stereome tube. Smaller bundles embedded in stereome tube. Larger bundles few in medullary tissue. Medullary tissue of thin-walled cells.

Elionurus hirsutus *Mun.*—Figs. 328, 329, 330. Deeply grooved on the upper surface. Lower surface furrowed below the larger veins. Margins pointed and with large stereome bundles. Hairs spiny, long and unicellular. Stomata more numerous on the lower surface. Articulation tissue extending between two surfaces near the margin and forming extensive tissue between the upper epidermis and veins towards the margin. Palisade cells forming complete girders round non-transcurrent smaller veins. Larger veins alternating with smaller ones and situated in a higher plane. Larger veins near the margin vertically transcurrent. Mechanical tissue in the leaf in the form of I-girders towards the margin, of isolated sub-epidermal girders on the lower surface and of stereome-ring inside the sheath round non-transcurrant smaller veins. Assimilatory tissue in the axis forming a continuous ring of chlorenchyma. Smaller bundles with complete sheaths and embedded in assimilatory tissue. Of the larger bundles the peripheral ones embedded in stereome tube and inner

ones found in the medullary tissue and enclosed in stereome rings. Mechanical tissue in the axis in the form of stereome tube. Medullary tissue of thick-walled cells.

Andropogon foveolatus *Del.*—Figs. 331, 332, 333. Not much grooved on either surface. Margin blunt and with large stereome bundles. Hairs unicellular, long and bluntly pointed. Articulation tissue one-layered groups. Palisade tissue and bundle-sheaths in the form of rings round smaller veins and of arcs on sides of vertically transcurrent veins. Mechanical tissue in the leaf in the form of I-girders in association with vertically transcurrent veins and of isolated sub-epidermal girders on the lower side of other veins. T. S. of the axis horse-shoe shaped. Mechanical tissue in the axis forming a sub-epidermal stereome tube. Assimilatory tissue absent in the axis. Smaller bundles embedded in stereome tube. Larger bundles few in the medullary tissue. Medullary tissue of thin-walled cells.

Andropogon annulatus *Forsk.*—Fig. 334. Not much grooved on either side. Margin pointed and with large stereome bundles. Hairs unicellular, long and bluntly pointed. Articulation tissue in the form of one layered groups. Palisade cells and sheath-cells forming complete rings round smaller veins and arcs on sides of vertically transcurrent veins. Mechanical tissue in the leaf in the form of I-girders in association with vertically transcurrent veins and of isolated sub-epidermal girders on the lower side of other veins. T. S. of the axis horse-shoe shaped. Mechanical tissue in the axis forming a sub-epidermal stereome tube. Assimilatory tissue absent in the axis. Smaller bundles embedded in the stereome tube. Larger bundles few in the medullary tissue. Medullary tissue of thin-walled cells.

Aristida funiculata *Rupr.*—Figs. 335, 336, 337, 338. Upper surface deeply grooved. Margins bluntly pointed and with large stereome bundles. Hairs spiny. Palisade tissue and sheath-cells forming complete girders round smaller veins and arcs on sides of vertically transcurrent veins. Mechanical tissue in the leaf in the form of I-girders in association with vertically transcurrent veins and of isolated sub-epidermal girders on the lower side. Mechanical tissue in the axis forming a stereome tube supplimented by sub-epidermal I-girders. Webs formed by unmixed vascular bundles or by strips of stereome. Assimilatory tissue in the axis chlorenchymatous. Larger bundles in the medullary tissue and few. Medullary tissue of thin-walled cells.

Aristida hirtigluma *Steud.*—Figs. 339, 340. Grooves on the upper surface not deep. Margin pointed and with small stereome bundles. Hairs spiny. Articulation tissue only in the upper half of mesophyll. Palisade tissue and sheath cells forming complete rings

round smaller veins and arcs on sides of vertically transcurrent veins. Mechanical tissue in the leaf forming sub-epidermal I-girders in association with vertically transcurrent veins and isolated sub-epidermal girders on the lower side. Assimilatory tissue in the axis of palisade cells with a layer of cells resembling sheath-cells on the inner side. Mechanical tissue in the axis in the form of a stereome tube supplimented by isolated sub-epidermal I-girders. Webs formed by mixed vascular bundles or by strips of stereome. Larger vascular bundles in the medullary tissue and numerous. Medullary tissue of thin-walled cells.

Gracilea Royleana *H. f.* Figs. 341, 342, 343, 344. Deeply grooved on both surfaces. Margins blunt with large stereome bundles. Stomata more numerous on the lower surface. Hairs spiny and situated at the angles on the axis. Articulation tissue in the upper half of the mesophyll. All veins vertically transcurrent. Smaller veins with complete sheaths. Mechanical tissue in the leaf forming I-girders. Assimilatory tissue forming arcs above the smaller vascular bundles. T. S. of the axis flattened on the inner side and semicircular and angled on the outer. Mechanical tissue in the axis in the form a stereome tube supplemented by sub-epidermal I-girders at the angles. Webs formed by mixed small vascular bundles. Larger vascular bundles all embedded in the stereome tube. Medullary tissue of thin-walled cells filled with starch grains.

Chloris villosa *Pers.*—Fig. 345. Grooves on the surfaces not deep. Epidermal cells toothed. Margins pointed and with small stereome bundles. Hairs spiny. Stomata more numerous on the lower surface. Articulation tissue extending between two surfaces. Palisade tissue forming arcs on sides of the veins. Veins vertically transcurrent. Bundle-sheaths complete round smaller veins. T. S. of the axis elliptical. Assimilatory tissue chlorenchymatous and placed in the plane of longer diameter. Mechanical tissue in the leaf in the form of I-girders and that in the axis in the form of a stereome tube and of a thin sub-epidermal layer of stereome. Smaller vascular bundles embedded in the stereome tube. Larger vascular bundles enclosed in stereome rings and numerous in the medullary tissue; medullary tissue of thick-walled cells towards the pariphery and of thin-walled cells in the centre.

Eleusine flagellifera *Nees.*—Figs. 346, 347, 348. Deeply grooved on the upper surface. Margins blunt and with large stereome bundles. Hairs spiny, longer and arising from articulation cells on both sides. Hairs spiny on the axis. Stomata more numerous on the lower surface. Articulation tissue extending between two surfaces. Palisade cells forming complete girders round smaller veins.

Larger veins vertically transcurrent. Upper and lower cells of sheaths of vertically transcurrent veins aqueous. Sheaths complete round the veins. Mechanical tissue in the leaf in the form of I-girders and of isolated sub-epidermal girders on the lower side above smaller veins. T. S. of the axis elliptical. Assimilatory tissue in the axis chlorenchymatous. Mechanical tissue in the axis forming a stereome tube supplemented by I-girders. Webs formed by unmixed small vascular bundles. Smaller vascular bundles forming webs. Larger vascular bundles in the medullary tissue, few and with arcs of stereome on the outer side. Medullary tissue of thin-walled cells.

Eleusine aristata *Ehrenb.*—Figs. 349, 350. Not grooved. Epidermal cells on the lower surface vertically elongated and papillose. Hairs short, unicelluler and bluntly pointed. Stomata more numerous on the lower surface. Articulation tissue extending between the surfaces. Palisade cells forming complete girders round smaller veins; veins provided with complete sheaths. Larger veins vertically transcurrent. Mechanical tissue forming I-girders supplemented by isolated sub-epidermal girders on the lower side below smaller veins. Assimilatory tissue in the axis forming groups of palisade cells. Mechanical tissue in the axis in the form of a stereome tube supplemented by isolated sub-epidermal girders alternating with I-girders. Webs formed by unmixed vascular bundles. Larger vascular bundles in the medullary tissue, few and with arcs of stereome on the outer side. Medullary tissue of thin-walled cells.

(*To be continued.*)

Plate XXXII.

311-317. *Scirpus maritimus.*

311. T. S. of the leaf-blade at the margin.
Oc. 4 Com.; Ob. 8 mm. Ap.

312. T. S. of the leaf-blade between the mid-rib and the margin.
Oc. 6 Com.; Ob. 8 mm. Ap.

313. Stoma on the leaf.
Oc. 8 Com.; Ob. 3 mm. Ap.

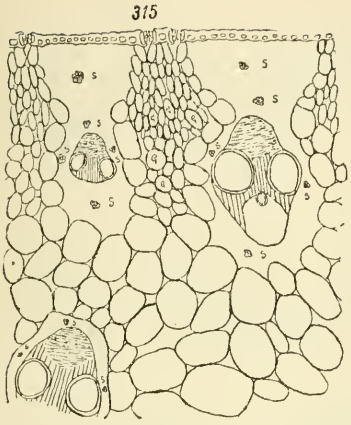
314. T. S. of the axis at the angle.
Oc. 4 Com.; Ob. 8 mm. Ap.

315. T. S. of the axis between the angles.
Oc. 6 Com.; Ob. 8 mm. Ap.

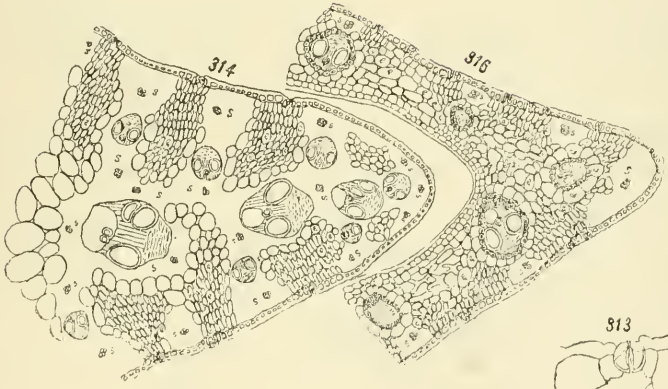
316. T. S. of the leaf-sheath enclosing the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.

317. Internal gland in the axis.
Oc. 6 Com.; Ob. 3 mm. Ap.

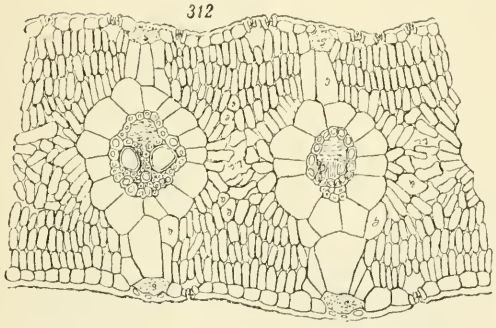
N.B.—To get the original dimensions multiply by 1·7.











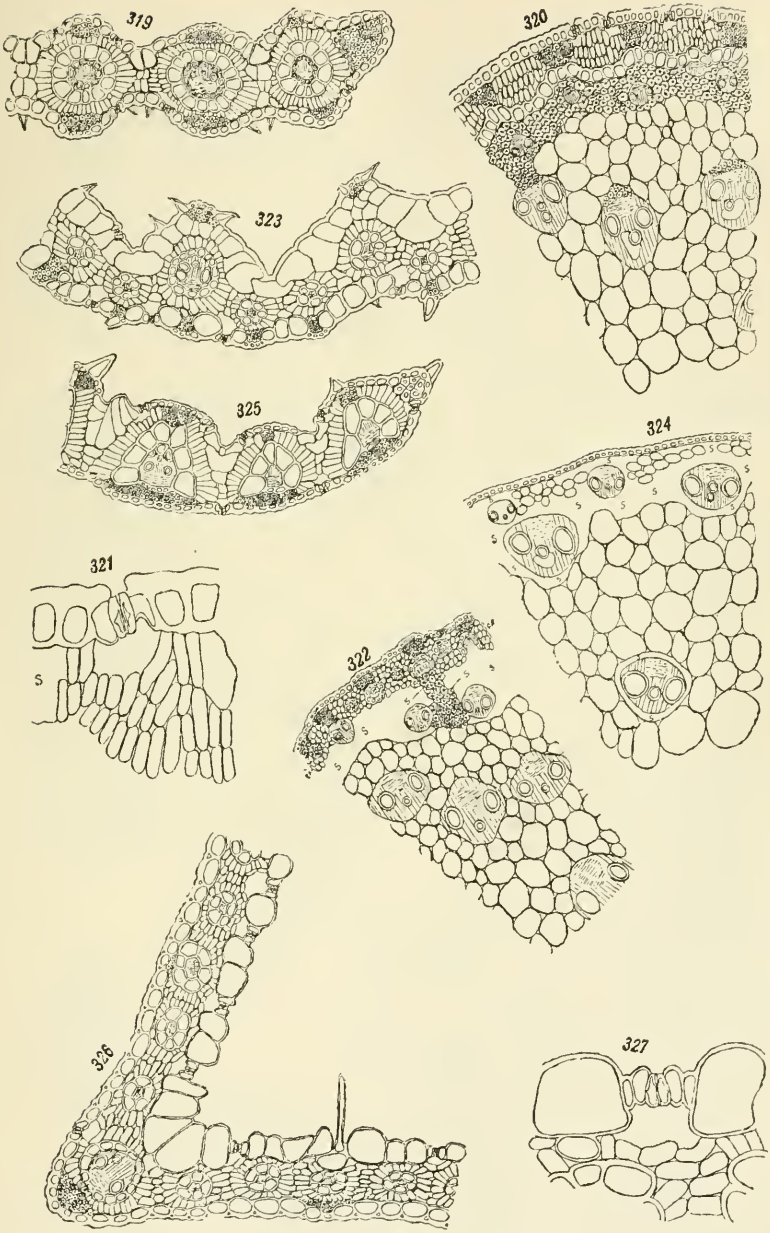


T. S. Sabnis del. PLATE XXXII.

Plate XXXIII.

319-321. *Panicum turgidum.*
319. T. S. of the leaf.
Oc. 4 Com.; Ob. 8 mm. Ap.
320. T. S. of the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.
321. Stoma on the axis.
Oc. 6 Com.; Ob. 3 mm. Ap.
322. *Panicum antidotale.*
T. S. of the axis.
Oc. 4 Com.; Ob. 8. mm. Ap.
323-324. *Cenchrus catharticus.*
323. T. S. of the leaf.
Oc. 6 Com.; Ob. 8 mm. Ap.
324. T. S. of the axis.
Oc. 6 Com.; Ob 8 mm. Ap.
325. *Latipes senegalensis.*
T. S. of the leaf.
Oc. 4 Com.; Ob. 3 mm. Ap.
326-327. *Elionurus Royleanus.*
326. T. S. of the leaf.
Oc. 6 Com.; Oc. 8 mm. Ap.
327. Stoma on the leaf.
Oc. 8 Com.; Ob. 3 mm.

N.B.—To get the original dimensions multiply by 1·7.

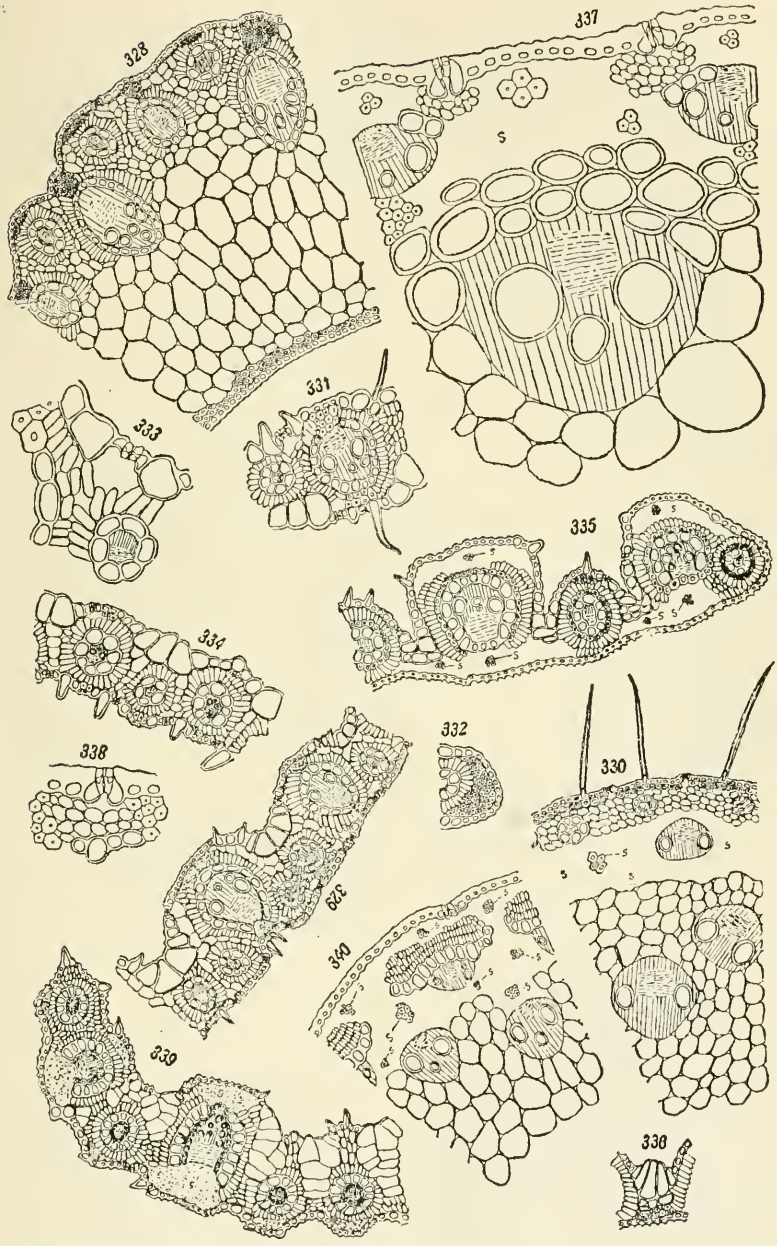


T. S. Sabnis del. PLATE XXXIII.

Plate XXXIV.

328-330. *Elionurus hirsutus.*
328. T. S. of the leaf at the mid-rib including the vascular bundle of the mid-rib.
Oc. 4 Com.; Ob. mm. Ap.
329. T. S. of the leaf between the mid-rib and the margin.
Oc. 4 Com.; Ob. 8 mm. Ap.
330. T. S. of the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.
331-333. *Andropogon foveolatus.*
331. T. S. of the leaf.
Oc. 6. Com.; Ob. 8 mm. Ap.
332. T. S. of the leaf showing the margin.
Oc. 6 Com.; Ob. 8 mm. Ap.
333. Stoma on the leaf.
Oc. 6 Com.; Ob. 3 mm. Ap.
334. *Andropogon annulatus*
T. S. of the leaf.
Oc. 6. Com.; Ob. 8 mm. Ap.
335-338. *Aristida funiculata.*
335. T. S. of the leaf.
Oc. 6 Com.; Ob. mm. Ap.
336. T. S. of the leaf showing the articulation tissue.
Oc. 6 Com.; Ob. 8 mm. Ap.
337. T. S. of the axis.
Oc. 6 Com.; Ob. 3 mm. Ap.
338. Stoma on the axis.
Oc. 6 Com.; Ob. 3 mm. Ap.
339-340. *Aristida hirtigluma.*
339. T. S. of the leaf.
Oc. 4 Com.; Ob. 8 mm. Ap.
340. T. S. of the axis.
Oc. 4 Com,; 8 mm. Ob. Ap.

N.B.—To get the original dimensions multiply by 1·7.

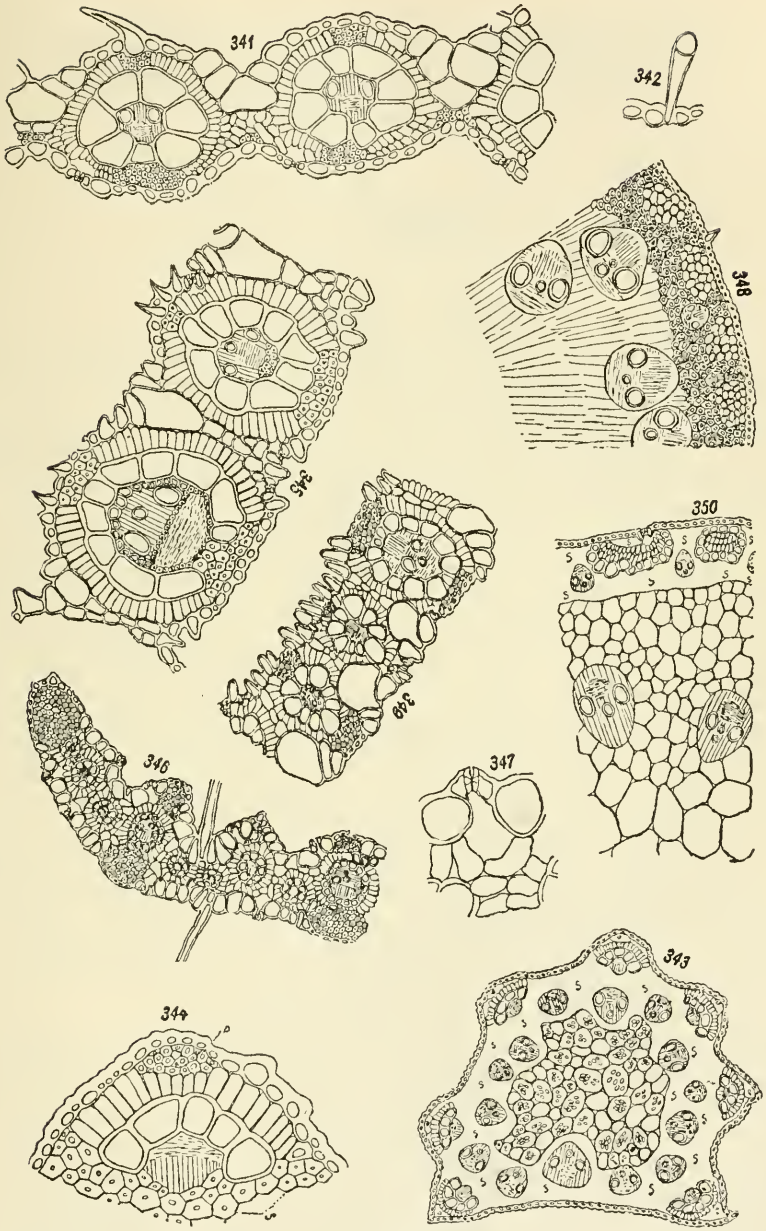


T. S. Sabnis del. PLATE XXXIV.

Plate XXXV.

341-344. *Gracilea Royleana.*
341. T. S. of the leaf.
Oc. 4 Com.; Ob. 3 mm. Ap.
342. Glandular hair on the axis.
Oc. 4 Com.; Ob. 3 mm. Ap.
343. T. S. of the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.
344. T. S. of the axis at the angle.
Oc. 6 Com.; Ob. 3 mm. Ap.
345. *Chloris villosa.*
T. S. of the leaf.
Oc. 4 Com.; Ob. 3 mm. Ap.
346-348. *Eleusine flagellifera.*
246. T. S. of the leaf.
Oc. 4 Com.; Ob. 8 mm. Ap.
347. Stoma on the leaf.
Oc. 6 Com.; Ob. 3 mm. Ap.
348. T. S. of the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.
349-350. *Eleusine aristata.*
349. T. S. of the leaf.
Oc. 6 Com.; Ob. 8 mm. Ap.
350. T. S. of the axis.
Oc. 6 Com.; Ob. 8 mm. Ap.

N.B.—To get the original dimensions multiply by 1·7.



T. S. Sabnis del. PLATE XXXV.

FOREST FORMATIONS AND SUCCESSIONS OF THE SAT TAL VALLEY, KUMAON HIMALAYAS

By

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Location and Climate.

The Himalayan range, the highest mountain range of the world, deserves far more attention from the ecological standpoint than it has received. It is given merely a passing notice by such authors as Schimper (10) and Warming (12). This survey of a limited area is given with the hope that it may stimulate the botanists of India to further researches in this most fruitful field.

Sat Tal is in the Kumaon Division, United Provinces, India, at a latitude of 29° 23′ north and a longitude of 79° 32′ east. It takes its name from the existence some time ago of seven lakes, probably produced by the blocking of the drainage by landsides. Three of these lakes remain, one of them being over 90 and another over 80 feet in depth.

The region included in this study is the drainage basin of these lakes which almost coincides with the Sat Tal estate and has a length from north to south of one mile and a width from east to west of one-half mile. This valley lies just behind the outer range of the Himalayas, the drainage to the south of it going rather directly to the plains. The lowest lake has an altitude of about 4160 ft. and the highest peak, that at the north end of the valley, of 5860 ft. Some of the observations, particularly those related to biotic factors, were made outside the above-mentioned area.

This valley was selected for this study because it is at the altitude in which the prevailing formations of the lower Himalayas meet and because the fact that it is a private estate which has for fifty years been protected from cutting, grazing, and cultivation as well as the fact that it is a depression relatively protected from both hot and cold winds give it the richest flora which the author has seen in any area of similar size in the Himalayas. Something of its actual wealth in species is shown by the fact that it contains about 75 species of trees and 65 species of shrubs. Great Britain has about 10 kinds of trees, and all Europe only 85 (1).

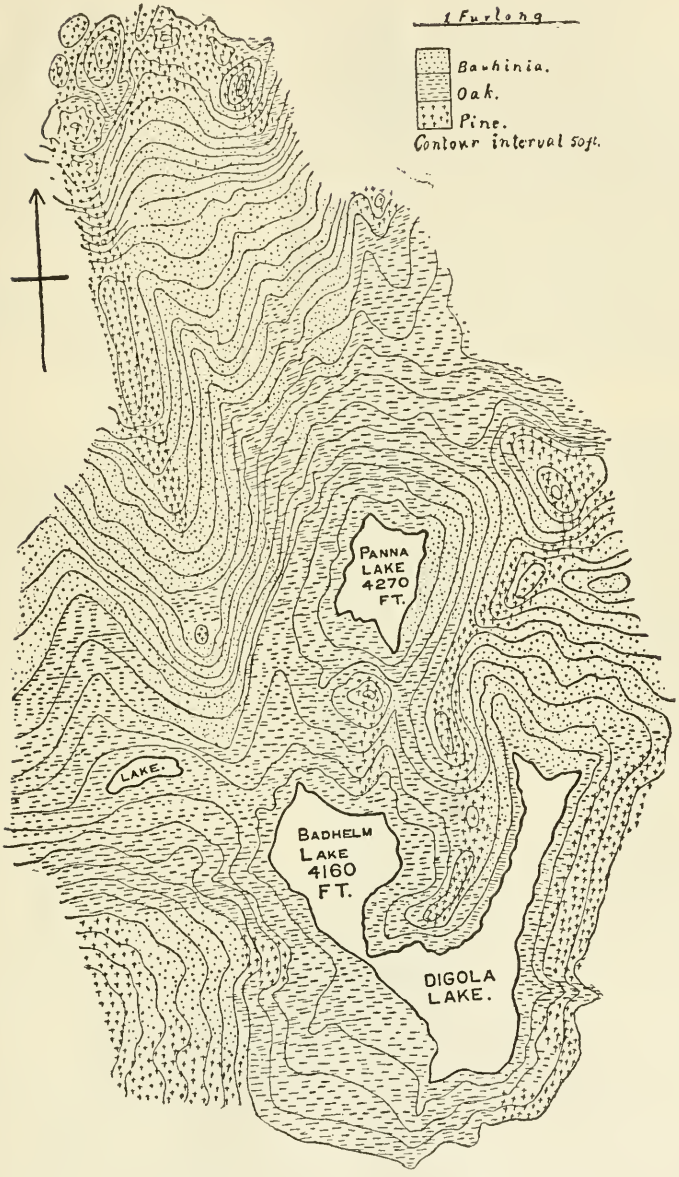


Fig. I. *Map of Sat Tal valley.*
Scale 17·6 cm. = 1 mile.

The average rainfall in the Sat Tal valley as recorded by Mr. A. C. Evans, proprietor of the estate, for the eight years from June, 1913 to May, 1921 was 85.02 inches. This corresponds pretty closely with the figures in the Naini Tal Gazeteer for the rainfall at Kathgodam at the foot of the outer range, 91.27 inches, and at Naini Tal about five miles from Sat Tal to the north-west and at an altitude of about 7000 feet, 97.49 inches (8). These places all lie in a general way on the outer slope of the outer range, for the highest peak of Sat Tal is at the north of the valley. The inner valleys of the Himalayas have considerably less precipitation.

The altitude above which frost is severe enough to affect vegetation is approximately 4000 feet. Sat Tal has an occasional hoarfrost, but the temperature rarely gets down to the freezing point.

Seasonal Periodicity of Vegetation.

The distribution of the rainfall by months is shown in Fig. II, 84 per cent. of the rain falls in four months—June, July, August and September. Hence there is in all the formations a striking seasonal periodicity based on the water supply. This is most marked in the lower or monsoon forest formation where the effect of the dry period is most intense. At the beginning of June, vegetation is at a comparatively low ebb, the monsoon forest trees being leafless and herbs being not much in evidence. With the first rains there is a marked revival of activity. The trees which have to this time remained leafless burst into leaf, a wealth of annual and fleshy rooted perennial herbs spring up, and there is germination of many tree seeds upon the forest floor, *e.g.*, those of the Bauhinias.

With the close of the rainy season much of the herbaceous vegetation ripens its seeds and dies to the ground. October brings a wealth of composite and labiate herbs, including goldenrods, asters and groundsels, which remind one of the forest floor of a climax oak forest in Europe or America. Already some of the monsoon forest trees such as *Bombax malabaricum*, *Garuga pinnata*, and *Erythrina suberosa* are losing their leaves. Winter deciduous trees of the oak forest, such as *Prunus puddum* and *Pyrus pashia*, become leafless about the same time. No part of the winter is too cold for the vegetative activities and even for the flowering and fruiting of much of the vegetation. *Prinsepia utilis*, a widespread pioneer rosaceous shrub of the oak forest, has festoons of blossoms in midwinter. About February the candle-like spikes of *Sapium insigne* appear.

From March to May is the hot season. Trees blossom profusely during the early part of this season, conspicuous among them being the legumes of the upper monsoon forest. *Bauhinia variegata* puts

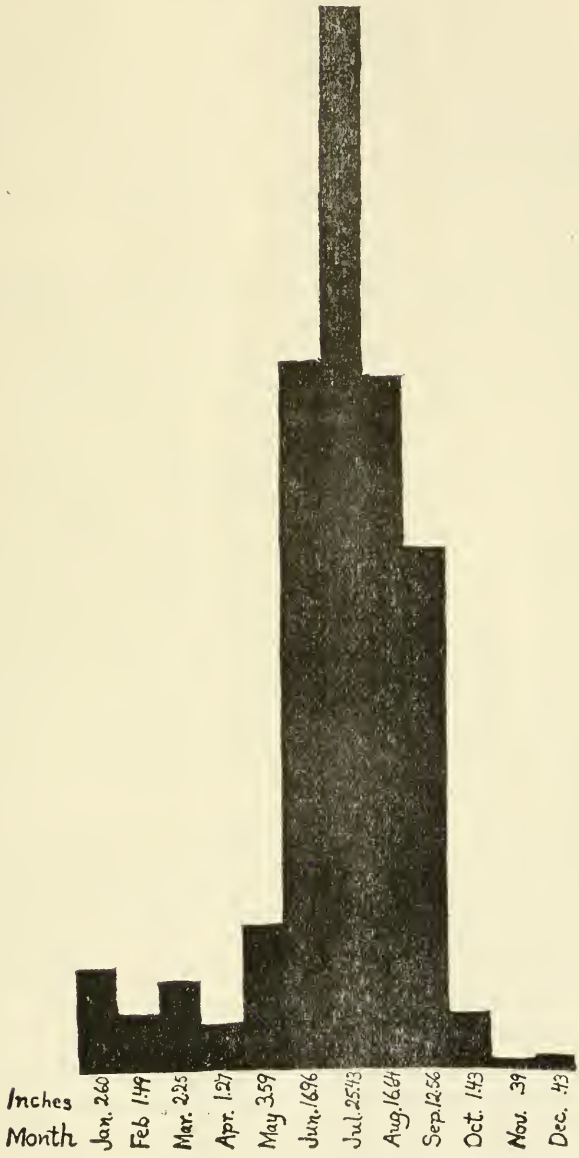


Fig. II. Distribution by months of the rainfall at Sat Tal.

out its masses of pinkish flowers and reminds one of the blossoming apple tree. *Erythrina suberosa* dots the woods with scarlet, *Indigofera atropurpurea* and *Ougeinia dalbergioides* with lavender, and *Caesalpinia sepiaria* with golden yellow. A number of early blooming herbs, such as geraniums and violets now come out. The deciduous trees of the oak forest develop their leaves until the beginning of the monsoon while the trees of the monsoon forest become increasingly leafless until about the same time. The highest recorded temperature is 92° in May, 1921.

The herbaceous vegetation at this level may be considered as constituting three fairly distinct seasonal groups. With the spring rise of temperature come mainly representatives of temperate zone families, such as *Ranunculaceae, Cruciferae, Caryophyllaceae, Violaceae, Geraniaceae, Rosaceae, Crassulaceae,* and *Compositae.* With the monsoon come mainly representatives of tropical families, such as *Begoniaceae, Gesneriaceae, Orchidaceae* and *Scitaminaceae.* In the cooler and less humid conditions following the monsoon come representatives of families which largely constitute the autumnal vegetation of the temperate zone, such as *Compositae* and *Labiatae.*

Monsoon Forest (Shorea and Bauhinia) Formations.

The monsoon forest grows over the whole area from the foot of the hills up to the crest of the ridge, about 4500 ft. high, which borders the Bhim Tal and Sat Tal lake valleys on the south, and occupies many of the exposed slopes and ridges within the valley. This is the typical forest described by Schimper (10) for tropical districts with pronounced dry seasons.

There are two types of this formation determined by altitude. From the base of the hills to about 3000 feet is a forest dominated by *Shorea robusta,* but having as important elements *Semecarpus anacardium* and *Bassia butyracea.* This type does not extend to the altitude of Sat Tal valley. It contains a good number of tree species, but Shorea is the climax form, producing an almost pure forest of tall straight black-barked trees which is able to hold its own against invaders. From 2500 to 4500 (in suitable exposures as high as 5500) feet the climax forest is marked by three species of Bauhinia. *B. variegata* is a spring-blooming tree, *B. retusa* an autumn blooming tree and *B. Vahlii,* the elephant creeper, a gigantic woody twiner. There is a good sprinkling of other legumes such as *Erythrina, Indigofera. Ougeinia, Dalbergia,* and *Caesalpinia.* This might be called the Legume forest or better, since the Bauhinias occupy a climax position, the Bauhinia forest. It contains numerous other deciduous trees such as *Grewia, Nyctanthes, Mallotus, Sapium, Odina.* This forest is found

only on the sunny faces of the Sat Tal valley, south, east, and west, and is with the exception of a few scattering outliers entirely absent from the higher valleys. Its upper limit is roughly 4000 feet. on north facing slopes and 5500 feet on south facing slopes.

The factors which induce the shedding of the old leaves and the development of the new deserve careful investigation. The end of May, 1921 was an unusually dry time in the Western Himalayas. At Sat Tal the rainfall for the eight dry season months, October, 1920 to May, 1921 inclusive, was 6·29 inches and was limited to two of these months. The rainfall for the corresponding period 1918-19 was 17·17 inches and was distributed through seven of the eight months. A comparison of notes on the vegetation in May of the two years shows that in almost all species of the deciduous forest the shedding of the old leaves occurred earlier in 1921 than in 1919. Hence it seems apparent that the shedding of the foliage is hastened by lack of humidity. On the other hand observations show that the putting out of new foliage by no means awaits the beginning of the monsoon rains. Schimper **(10)** says that the trees of monsoon districts renew their foliage at or immediately before the commencement of monsoon rains, but he throws no light on the nature of the stimulus which causes leafing in anticipation of rain. The chief surprise that the writer has met in his observation of the monsoon forest on the plains of India is the fact that many, indeed most, species go through the exceedingly severe heat and drought of May and June with young tender foliage. At Sat Tal there were no showers in May, 1921 to indicate the coming of the monsoon, yet the leafing of the monsoon trees had proceeded further than in 1919 when such showers did occur. The species latest to put forth their foliage are *Nyctanthes arbortristis*, *Grewia tiliaefolia* and *Euphorbia Royleana*, yet in numbers of *Grewia* trees and in one *Euphorbia* leaves were coming out before the end of May. Instead of being a benefit to the tree, preparing it to profit from the rains without loss of time, this early leafing seems in some cases a real detriment, for the drying of the tender foliage has gone on to such an extent as to threaten the life of trees and shrubs of several species.

It may be that the development of leaf buds requires a certain period of incubation. In some cases greater insolation seems to induce earlier leafing. Temperature-controlled experiments or observations checked with a thermograph are most desirable to test this point. The way in which temperature most probably acts upon leafing is by hastening the maturation of the fruit. In at least twenty of the monsoon forest species, notable among which are the tree *Bauhinias*, *Erythrina suberosa*, *Ougeinia dalbergioides*, *Odina Wodier*,

Sapium insigne, the *Stercufunalias*, and *Nyctanthes arbortristis* the leaf buds do not open until the fruit is mature. Evidence for this is found in the fact that young non-fruiting trees often develop their leaves before the fruiting ones do so, that pollarded non-fruiting branches on fruiting trees are the first to leaf out, that the male trees of such dioecious species as *Odina* begin to leaf while the female trees bearing immature fruit show no signs of leafing, that trees which for any other reason are less cumbered with fruit are more prompt to leaf. Another example which might apply here is that *Bauhinia retusa*, which blooms in the autumn and matures its fruit early in the spring, is in full leaf before *Bauhinia variegata*, which blooms in the spring and matures its fruit later, has commenced to leaf.

An exposed hillside generally has a strikingly less leafy appearance in May than has a sheltered hillside or a ravine. Examination shows that this is because the floral population of the exposed hillside is made up mainly of such trees as *Grewia*, *Nyctanthes*, and *Euphorbia*, which are tardy in leafing, while the sheltered area has a larger number of evergreens and of early-leafing deciduous trees such as *Bauhinia retusa*. It is a matter of survival, for evergreens and *Bauhinia retusa* could not persist in a place of severe exposure.

Almost all the vegetation is to a high degree deciduous. The leaf fall occurs irregularly, as compared with that of the temperate zone winter deciduous forest. Some of the trees are bare in October and others retain their leaves until just before the rains.

Broad-leaved Sclerophyllous (Quercus incana) Formation.

This forest is made up largely of evergreen trees and shrubs, but with an admixture of winter deciduous forms. Roughly about 60% of the species belong to the former and 40% to the latter class. The dominating tree is *Quercus incana* which is easily distinguished from the other Himalayan oaks by the silvery white lower surface of the leaves. It is the lowest of three altitudinal oak zones, and extends from the upper limit of the Bauhinia forest to about 8,000 feet. *Quercus dilatata* extends from 7,500 to 9,000 and *Quercus semecarpifolia* from 9,000 to 11,000. The latter forms occur at altitudes higher than that of the Sat Tal valley. *Q. incana* renews its leaves in March and April, the other species somewhat later. At no time are the trees entirely bare, as the new leaves appear while the old ones fall.

Associated with the oak are three members of the Laurel family which occupy stream depressions and are probably hydrarch pioneers. *Rhododendron arboreum* and *Pieris ovalifolia* of the Heath family

are characteristic trees of the climax oak forest. They require more shaded and moist situations than does the oak, hence in this valley they are found only on north slopes.

The distribution of the oak forest is evidently determined by the degree of protection against dessication. Its moisture requirement is greater than that of the Bauhinia forest for it occurs in depressions, stream valleys, north slopes, and other sheltered aspects. The ridge which forms the watershed to the west of the valley at one place is interrupted by a flat shelf which receives the seepage from the higher portions of the ridge. The adjoining portions of the ridge are occupied by Bauhinia forest but this shelf has a small oak grove. The altidudinal distribution of the oak may be a matter of humidity. As I have pointed out the rainfall on the south slopes of the first high range varies but little with altitude. But, because of the lower temperature, the relative humidity, hence the moisture effective for vegetative growth, is greater at the higher altitudes.

Coville (5) has found that in many cases the trees and shrubs of cold climates will not resume growth after dormancy without a certain amount of chilling. The necessity for chilling probably determines why many of the cold region plants, as for example the apple, will not grow to advantage in the tropical regions. One wonders then to what extent temperature itself is a factor in determining the altitudinal range of the hill vegetation.

Broad-leaved sclerophyllous woodlands, according to Schimper (10), are characteristic of warm temperate regions with moist winters and dry summers. Except within the range of a mountain climate they are found only in certain coastal regions. In these regions vegetation is subject to short and irregular periods of rest which may be due either to the cold of winter or to the drought of summer. The winter is not altogether favourable to plant growth because of the low temperature neither is the summer altogether favourable because of the low water supply. By constant retention of leaves the trees of these forests are able to take advantage of the favourable periods in either season.

The climate of the region occupied by this forest in the Himalayas differs from the climate of a typical sclerophyllous region in the fact that the rainy season does not coincide with the winter. Nevertheless the fact remains that there are at all seasons periods which are favourable to plant activity. It would be a loss to the plant to enter these short periods without foliage.

Bulbous and tuberous plants, such as are common in the coastal sclerophyllous regions, are also abundant here. But unlike the former regions this Himalayan formation contains a profusion of

woody climbers and of epiphytic mosses, lichens and ferns, and seed plants such as the *Orchidaceae* and *Peperomia refleta* of the Piperaceae. The presence of epiphytes would indicate a dry season of less severity than is found in the coastal xerophyllous regions.

Pinus longifolia Formation.

Pinus longifolia occurs in almost pure forests in an altitudinal zone slightly lower than that of *Quercus incana*. On the steep north slope of the canyon separating Sat Tal from Naini Tal there are a few pines at 2,000 feet. Very little pine forest is seen, however, until 4,000 feet is reached, where it continues upward to about 6,500 feet. Hence it will be seen that it overlaps a small margin of the Bauhinia formation and over half of the oak formation. It however occupies an edaphic situation distinct from that of the oak. It occurs on the hilltops and ridges and more exposed flanks of the hills. On the north slope of the Sat Tal valley it descends from the crest to meet the oaks. On other hill slopes it descends from the crests along the ridges into the Bauhinia forest in much the same manner as the oaks ascend from the valley base along the stream channels. On peaks between 4,000 and 6,500 feet in height it is usual to find pines occupying the highest and most exposed position. Higher peaks, such as are found a few miles further to the northeast, have pines only on the ridges, the summits being occupied by oaks.

Pinus longifolia is a strikingly xerophytic species. In May old leaves have mostly fallen while the new are appearing, so that the tree is almost bare. Much sun reaches the ground between the trees, and pine seedlings flourish, so the forest renews itself freely. The ground is covered most of the time by a layer of fallen pine leaves, which seem to prevent the extensive development of herbs and grasses. Shrubs are limited to such xerophytic pioneers as *Aechmanthera*. Other species of trees found sparingly mixed with the pines in the more sheltered parts of the forest are *Englehardtia spicata*, *Castanopsis tribuloides* and *Myrica Nagi*.

Factors Determining Distribution of Formations.

Clearly the monsoon forest is adapted to extremes of seasonal humidity and to a temperature which does not descend below freezing. The pine forest is adapted to dry exposures within certain altitudinal, hence temperature, limits. The *Quercus incana* forest is adapted to humid situations within altitudes slightly higher, hence temperature limits slightly lower, than those which make the upper and lower boundaries of the pine forest.

It is the task of dynamic ecology to point out the order of succession by virtue of which existing formations come into being. Cowles (6) and Clements (4) have done much toward the elucidation of this problem on the western continent. But little has been done in India. Dudgeon (7) has pointed out the probable succession in the Upper Gangetic plain, beginning with pond vegetation. He feels that the intense human competition prevents vegetation from reaching the climax stage which would otherwise occur. The inquiry arises what would be the order of succession of these formations at Sat Tal if they were left to themselves. Here, as in the plains, the human disturbance is great and increases the difficulties in the solution of the problem. Sat Tal valley has been protected, but not for a long enough period to enable us to read the whole story.

In the narrow altitudinal zone, 4,000 to 5,000 feet, where all three formations are found, the pine and the Bauhinia seem to be xerarch pioneers and the oak the climax toward which the former two tend. Evidences were found in my study that the oak invades the pine regions. Oak seedlings could be seen frequently along the borders of the pine. On the other hand pine seedlings do not thrive in the oak forest because of the continual shade. In such situations could be found pines thirty years of age which do not exceed 10 feet in height. In this particular altitude the oak forest seems to be encroaching on the Bauhinia. When oaks become established it is probable that their shade is too dense for the establishment of Bauhinia seedlings, which germinate in the sunny Bauhinia forest at the very beginning of the rains. In other words, the oak appears to be the climatic climax in the Sat Tal valley. It must be remembered, however, that the Bauhinia formation is the climax one for the altitudinal zone just adjoining and below that in which the oak is climax. In the zone of the Bauhinia, the oak occurs as an edaphic hydrach pioneer in stream valleys, lake depressions and shaded slopes and tends, as the contour becomes more level to give way to the Bauhinia. As between the pines and the Bauhinias it is probable that the latter invades the former in edaphic situations favorable to Bauhinias. The pine forest is, as has been stated, singularly free from other plants, not excluding epiphytes and lianas. But at times one can see a pine tree overgrown and weighted down by *Bauhinia Vahlii*. The pine, then, seems to be mainly restricted to well-drained and exposed situations above the altitudinal range of the Bauhinia and to situations which, although within the altitudinal range of the latter, are on north exposures and hence probably subject to low temperatures for periods too long to permit Bauhinia to get a foothold.

Successions within the Formations

The three formations whose interrelations we have noted are themselves advanced stages in the topographical succession. At many places in and about this valley may be seen plant groups which do not fit into any one of the three but which form an initial stage leading to one of the three. As a topography tends to advance from a rough tract to a plain, the hills being levelled by erosion and the valleys filled by deposition, so plant societies tend to advance from those of extreme dry or extreme wet situations to the climax form which occupies a situation of moderate water supply.

I. Xerarch Topographical Successions.

A topography may be dry because,—

(*a*) It is so located that it receives a small amount of rainfall.

(*b*) It is so located as to be subject to a large amount of evaporation.

(*c*) The slope is such as to permit rapid drainage of water.

(*d*) The substratum is impervious to water.

Much work could with profit be done toward the determination of the local distribution of rainfall in the Himalayas. Certain places such as Naini Tal have a high rainfall because a funnel-shaped valley catches the incoming clouds and conveys them into a pocket surrounded by hills. Interior valleys receive less rainfall than the outer slopes because the air has given up a large proportion of its water vapor by the time it is forced over the crest of the outer range. It is most interesting during the monsoon to see how almost every day the clouds pass through gaps in the outer ridge to move almost on a level until they strike higher elevations further within the system. As the hills became eroded and the valleys filled there would of course be changes in the precipitation and with these we might expect vegetational changes. But the course of these changes is so slow that we can get little direct evidence regarding them.

A striking difference is observable whenever the north slope and the south slope of a valley are compared. The former is well wooded, while the latter is often an expanse of grassland with a little forest of a xerophytic type in ravines and sheltered places. This difference becomes more marked in the Himalayas as one goes westward to sections having less rainfall. In the Chakrata region, for example, the forest abruptly vanishes as the crest is reached or as the slope turns from the north to a direction of greater exposure to the sun. The

difference here is probably purely a matter of evaporation. The south slope, being exposed to the sun more directly and for longer periods, will not retain moisture enough to permit the oak forest to become established.

A precipitious slope will in general not allow trees to get a foothold, with the exception of special scrambling forms such as *Ficus foveolata*. With time such slopes become more gentle and support a more luxuriant forest vegetation.

An exposed rock is occupied by lichens. These are followed by xerophytic mosses, herbs, grasses and sedges and finally by shrubs and trees, the trees passing from xerophytic to mesophytic.

A typical xerarch succession then would be lichens, mosses, grasslands, *Euphorbia*, pine, oak. Instead of the pine there might be substituted, following *Euphorbia*, such semi-shrubby pioneers as *Woodfordia, Flacourtia and Nyctanthes*, then the *Bauhinia* formation, finally the oak forest.

In parts of this valley and the neighboring region are steep slopes of shale or other soft rock which readily crumbles giving rise to landslips with well-developed talus slopes. Both the exposed rock face and the talus have contours so temporary that their occupation by plants may be prevented for years. When finally the contour becomes more permanently established the first plants to appear are generally xerophytic grasses and sedges with an admixture of ruderal herbs, such as *Rumex hastatus* and the American *Tridax procumbens* and *Oenothera rosea*. These are followed by shrubs, among which the *Berberis-Rosaceae* group is often prominent, and the shrubby vegetation very gradually gives way to the climatic forest. If shrubs and trees which have the power of producing adventitious buds from the roots have grown previously on the slope these may contribute largely to the new population by suckering from the exposed roots on the denuded area or by the continued growth of the slumping vegetation on the talus slope.

Euphorbia royleana, the most extreme xerophyte among the trees of this region, is admirably fitted for the place it fills. Its fleshy angled cactus-like stems hold large quantities of water and do the greater part of the synthetic work, the leaves being very transient.

The shrubby formation of *Woodfordia, Nyctanthes* and *Flacourtia* occupies considerable areas on the south-facing slope at the north end of the valley. It is for the most part a relatively dense growth, difficult of penetration, but the individual members are low, usually not over twice the height of a man. *Woodfordia* is a pioneer which is often met with on bluffs and even in stream valleys in the plains as well as in the lower hill country.

II. Xerarch Biotic Successions.

Man's influence shifts vegetation from the mesophytic to the xerophytic level. Forests are burnt, cut, grazed or cleared for cultivation with the result that the land becomes more exposed to sunshine, the moisture-retaining undergrowth largely disappears, the moisture-absorbing humous soil often becomes less abundant and in general the plants which require considerable humidity give way to those which can endure more rigorous conditions so far as water supply is concerned.

Fires were wide-spread during the drought of May, 1921 and caused an appalling destruction of vegetation. The hill villager habitually burns the dry grass so that the fresh grass may get a better start at the outset of the monsoon. Fires started intentionally or accidentally spread through all three of the forest types and, helped along by the high winds, the dryness of the vegetation, and the large quantity of fallen leaves, were exceedingly difficult to conquer. The difficulty was greatest and the destruction most marked in the pine forest because of the greater inflammability of fallen leaves and twigs as well as of standing trees.

The young trees are damaged but older ones escape. Hence it is that we frequently find in the pine forest large trees with an undergrowth of young trees of a uniform age, the intermediates having been killed by fire just following which the young ones come from seed. Osmaston (9) says that no fire, unless helped by trimmings at the base of the tree can kill *Pinus longifolia* which is over 100 feet high. These large trees will reseed the area. Champion (3) says that in burnt areas pine seedlings grow to one foot in four years while in unburnt areas they take six years to attain this size. This he attributes to (*a*) manuring by ashes, (*b*) diminished competition of herbs, (*c*) increased light due to thinning of covering crown. Smithies (11) says "The intense light-demanding nature of the chir (*Pinus longifolia*) is too well known to require comment. Nevertheless the shade of a mature chir forest is never sufficient to stop the young seedlings from springing up and establishing themselves although their further development is checked unless they are completely freed of overhead cover."

So the natural course seems to be for pine seedlings to follow a fire in a pure pine forest. If it is a mixed pine and oak forest the results may be different. Champion (3) calls attention to the wonderful capacity of oak, *Rhododendron* and *Pieris* for developing dormant buds after a fire if only a narrow strip of the bark remains alive. Such survivors, he says, will often be found where the intermingled chir has been destroyed and, if in any numbers, will remove all chances of chir occupying the same area again. This appears, then, to be a

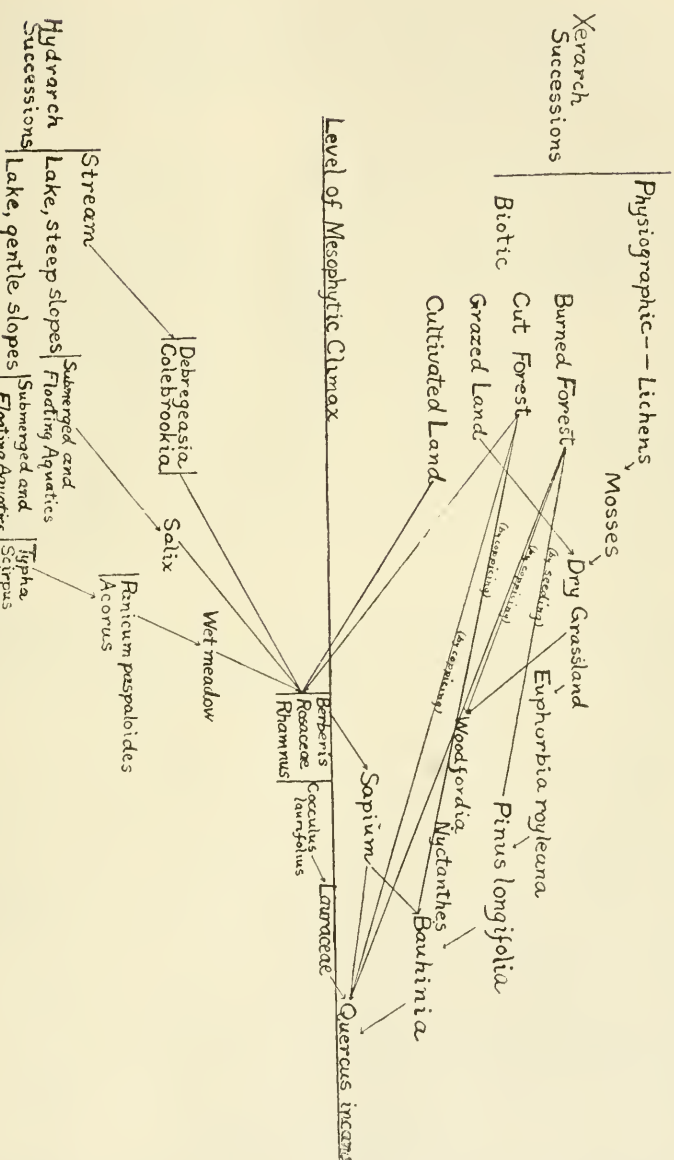


Fig. III. Diagram showing some of the more frequent successions in the Sat Tal Valley.

case in which a xerophytic retrogression might hasten the ultimate appearance of climax mesophytic conditions.

In the Bauhinia forest, *Euphorbia Royleana*, on account of its succulence, resists fire better than any other plant of its size. But here, as in the pine and oak forests, practically all the shrubs and younger trees succumbed. The course of plant succession is everywhere greatly affected by burning.

The cutting of timber, likewise a retrogression to the xerophytic, might hasten also the ultimate coming of the mesophytic oak forest, because the oak coppices freely, the pine not at all. The oncoming forest is usually preceded by a jungle of Rosaceous shrubs (*Prinsepia utilis*, *Crataegus crenulata*, *Pyrus pashia*, *Rosa moschata*, *Rubus ellipticus*) with which are mingled *Berberis asiatica* and *Rhamnus virgatus*. The duration of the shrubby stage depends largely on the abundance of the sclerophyllous trees left to coppice, for they are good coppicers. It depends furthermore on the extent to which cutting continues. There is no tree in the region more sought after than the oak. Used for fuel, for fertilizing the land, for thatching, for tanning and for cattle fodder, the wonder is that it maintains a foot-hold at all. The Bauhinias also are much cut, but readily spring up after cutting.

Grazing does not, of course, greatly affect the large trees. It effectually keeps down the seedlings of most trees and gives rise to a grassy forest. When persisted in, as the old trees die, a grassland results which must go through the xerophytic stages before the mesophytic forest can be renewed.

Cultivation is more serious than mere cutting because the stumps are grubbed out and the chance for coppicing removed. Preparation for cultivation involves contouring and terracing of the land. The place most suited for the entrance of vegetation is the terrace edge. Its first conspicuous flora is the aggregation of rosaceous herbs mentioned above with such others as *Berberis*, *Rhamnus* and *Clematis*. These may be followed by *Euphorbia* and *Sapium* which lead to the *Bauhinia* or the oak, more commonly the latter in the Sat Tal altitude. In Sat Tal valley on a flat that was cultivated over fifty years ago the large oaks which make up the bulk of the forest can be recognized as growing on old terrace edges.

Hydrarch Successions.

In this region are three classes of habitats with more than the normal amount of water,—streams of the wet season, lakes with steep sloping shores, such as the large lakes which give the name to Sat

Tal, and lakes with gently sloping shores such as a swampy lake just to the north-east of the valley.

Streams are occupied by such pioneers as *Debregeasia hypoleuca* of the Nettle Family and *Colebrookia oppositifolia* of the Mint Family, then the rosaceous shrubs, then trees of the Laurel Family with perhaps a few Rhododendrons which have temporarily gone a little below their normal range, then, in the altitude of Sat Tal valley, generally the oak climax.

Lakes with steeper shores have following the aquatics of deep water the willow, *Salix daphnoides*, near the water's edge. This adapts itself to the shifting seasonal water level by putting out roots at high water mark which hang high and dry when the water is low. As the lake decreases for topographical reasons, the willow is followed by rosaceous shrubs leading ultimately to the oak.

Lakes with gentle slopes, or swamps, have a large quota of submersed and floating aquatics. These are succeeded by *Typha angustata, Scirpus* spp., and *Polygonum lanigerum*, which are followed, as the water becomes more shallow, by *Acorus calamus* and *Panicum paspaloides*. Later comes the wet meadow and then the *Berberis-Rosaceae* formation leading to the oaks.

Special Features of the Vegetation.

About fifteen of the tree and shrub species in the valley are above the altitudinal range given for them by Brandis (2). Probably the fact that the valley is a depression protected from cold winds by the peak to the north, has allowed plants to grow out of their ordinary range.

A noteworthy feature of this altitude in the Himalayas is the abundance of lianas. Over twenty of the woody plants in the appended species list are climbers, to say nothing of many climbing herbs. A single tree was noticed which supported eight different species of climbers. *Bauhinia vahlii* is the king of lianas here. The Naini Tal Gazeteer (8) states that at times it grows so profusely that a single plant will cover a quarter of an acre of forest. It has been found a great pest to the forester as it overshadows and stunts the growth of many trees. So prolifically does it coppice that the foresters have difficulty in suppressing it. The valley has three genera of climbing aroids, four species of *Vitis*, and numerous leguminous climbers, climbing figs., etc. One of the most widespread lianas is the common ivy. Partaking of the nature of both lianas and epiphytes, and embracing tree trunks with a network of roots often to the extent of considerable injury to the tree embraced are certain species of Ficus, as *F Rumphii*, (the so-called " strangling figs ") and *Heptopleurum venulosum*, a member of the Araliaceae.

Epiphytes are prominent in this region. They consist mostly of mosses, ferns and orchids. The six or eight species of epiphytic orchids seem rather more abundant in the Bauhinia forest. Their blossoming period is mainly during the dry or the early part of the rainy season when the trees are relative devoid of foliage. As they have entomophilous flowers this habit seems especially appropriate. The ferns and mosses are more abundant on the oak, the rough shaggy bark of which furnishes them a better lodging than do the more smooth-barked trees of the Bauhinia woods. Frequently associated with them is *Peperomia reflexa*, a curious member of the Piperaceae. Lichens are abundant and often conspicuous, particularly on the oak. Still they are less in evidence than in the more humid forests of higher altitudes where several long thread-like *Usnea* species abound. A lichen was found growing on a leaf of an evergreen *Machilus* at Sal Tal.

Parasites of the *Loranthaceae* are wide-spread, there being three species of *Viscum* and two species of *Loranthus* in the neighborhood. The oak is one of the most affected trees, but we find *Viscum album* on the willow and some of the species on still other trees. *Cuscuta reflexa*, a dodder widely distributed over India, is found here.

Aechmanthera tomentosa is an interesting undershrub, related to *Strobilanthes*. It is found in all three of the forest types but is almost confined to the east side of the valley. It has the peculiarity of blooming only at long intervals, the common report is every twelfth year. Mr. Evans reports it as having bloomed profusely in 1907 and again in 1919. When it blooms it gives a gorgeous purple tinge to the whole landscape. After blooming it dies and the next crop comes from the seed.

Species of Woody Plants Observed.

BAUHINIA FOREST.

Acanthaceae

Aechmanthera tomentosa Nees.

Anacardiaceae

Odina wodier Roxb.
Pistacia integerrima Stewart.

Araliaceae

Heptopleurum venulosum Seem.
Heteropanax fragrans Seem.

Bixaceae

Flacourtia Ramontchi L' Herit.

Burseraceae

Garuga pinnata Roxb.

Celastraceae

Celastrus paniculata Willd.

Combretaceae

Terminalia belerica Retz.
„ tomentosa W. and A.

Compositae

Blumea aromatica DC.
Leucomeris spectabilis Don.

Euphorbiaceae

Bridelia montana Willd.
Euphorbia Royleana Bois
Flueggia microcarpa Blume.
Glochidon velutinum Wight.
Mallotus philippinensis Muell.
Phyllanthus Emblica L.
Sapium insigne Benth.

Juglandaceae
Englehar dtia spicata Blume.
Labiatae
Colebrookia oppositifolia Smith.
Leguminosae
Bauhinia Vahlii W. and A.
„ variegata L.
„ retusa Ham.
Cassia Fistula L.
Caesalpinia sepiaria Roxb.
Erythrina suberosa Roxb.
Flemingia fruticulosa Wall.
Milletia auriculata Baker.
Mimosa rubicaulis Lam.
Ougeinia dalbergioides Benth.
Pueraria tuberosa DC.
Loganiaceae
Buddleia asiatica Lour.
Lythraceae
Woodfordia floribunda Salisb.
Malvaceae
Bombax malabaricum DC.
Moraceae
Ficus clavata Wall.
„ Cunia Ham.
„ hispida L.
„ infectoria Roxb.
„ Roxburghii Wall.
„ Rumphii Blume.
Morus serrata, Roxb.
Myrtaceae
Eugenia Jambolana Lam.
Oleaceae
Jasminum arborescens Roxb.
Nyctanthes arbortristis L.
Pittosporaceae
Pittosporum eriocarpum Royle.
Rubiaceae
Hamiltonia suaveolens Roxb.
Pavetta indica L.
Samydaceae
Casearia tomentosa Roxb.
Santalaceae
Osyris arborea Wall.
Sapotaceae.
Bassia butyracea Roxb.
Sterculiaceae.
Sterculia fulgens Wall.
„ villosa Roxb.
Tiliaceae.
Grewia oppositifolia Roxb.
„ tiliaefolia Vahl.
Triumfetta rhomboidea Jacquem.
Verbenaceae
Caryopteris Wallichiana Schau.
Holmskoldia sanguinea Retz.
Premna barbata Wall.

PINE FOREST.

Acanthaceae
Aechmanthera tomentosa Nees.
Coniferae
Pinus longifolia Roxb.
Fagaceae
Castanopsis tribuloides A. DC.
Quercus incana Roxb.
Juglandaceae
Englehardtia spicata Blume.
Myricaceae
Myrica Nagi Thunb.

OAK FOREST.

Acanthaceae
Aechmanthera tomentosa Nees.
Aceraceae
Acer oblongum Wall.
Anacardiaceae
Pistacia integerrima Stewart.
Rhus Cotinus L.
„ Wallichii H. f.
Apocynaceae
Trachelospermum fragrans H. f.
Araliaceae
Hedera Helix L.
Macropanax oreophilum Miq.
Araceae
Pothos scandens L.
Raphidiophora glauca Schott.
Asclepiadaceae
Hoya longifolia Wall.
Berberidaceae
Berberis asiatica Roxb.
Caprifoliaceae
Lonicera quinquelocularis Hardw.
Celastraceae
Euonymus Hamiltonianus Wall.
Combretaceae
Terminalia tomentosa W. and A.

Ericaceae

Pieris ovalifolia D. Don.
Rhododendron arboreum Sm.

Euphorbiaceae

Andrachne cordifolia Muell.

Fagaceae

Castanopsis tribuloides A. DC.
Quercus incana Roxb.

Gramineae

Arundinaria falcata Nees.

Hypericaceae

Hypericum cernuum Roxb.

Ilicaceae

Ilex excelsa Wall.

Lauraceae

Machilus Duthei King.
„ odoratissima Nees.
Phoebe lanceolata Nees.

Labiatae

Plectranthus rugosus Wall.
Pogostemon plectranthoides Desf.

Leguminosae

Albizzia Julibrissan Durazzi.
„ stipulata Boivin.
Caesalpinia sepiaria Roxb.
Dalbergia sericea D. Don.
Flemingia congesta Roxb.
„ strobilifera R. Br.
Indigofera atropurpurea Ham.
„ Gerardiana Wall.
Mimosa rubicaulis Lam.
Sophora mollis Graham.

Liliaceae.

Asparagus adscendens Roxb.
„ filicinus Ham.
Smilax aspera L.
„ Roxburghiana Wall.

Loranthaceae

Loranthus elatus Edgw.
„ vestitus Wall.
Viscum album L.
„ articulatum Burn.
„ japonicum Thunb.

Meliaceae

Cedrela toona Roxb.

Menispermaceae

Cissampelos Pareira L.
Cocculus laurifolius DC.
Stephania elegans H. f. and T.

Moraceae

Ficus foveolata Wall.
„ palmata Forsk.

Myricaceae

Myrica Nagi Thunb.

Myrsinaceae

Myrsine africana L.

Myrtaceae

Eugenia Jambolana Lam.

Oleaceae

Jasminum dispermum Wall.
„ grandiflorum L.
Olea glandulifera Wall.

Ranunculaceae

Clematis Gouriana Roxb.

Rhamnaceae

Hovenia dulcis Thunb.
Rhamnus triqueter Wall.
„ virgatus Roxb.
Sageretia oppositifolia Brongn.

Rosaceae

Crataegus crenulata Roxb.
Prinsepia utilis Royle.
Prunus Puddum Roxb.
Pyrus Pashia Ham.
Rosa moschata Mill.
Rubus ellipticus Smith.
„ lasiocarpus Smith.
„ paniculatus Smith.
Spiraea vaccinifolia D. Don.
Stranvesia glaucescens Lindi.

Rubiaceae

Randia tetrasperma Roxb.

Rutaceae

Citrus Aurantium L.
Murraya exotica L.
„ Koenigii Spreng.
Toddalia aculeata Juss.
Xanthoxylum alatum Roxb.

Salicaceae

Salix daphnoides Villars.

Sapindaceae

Aesculus indica Calebi.

Styraceae

Symplocos crataegoides Ham.

Ulmaceae

Celtis australis L.

Urticaceae

Boehmeria macrophylla Don.
Debregeasia hypoleuca Wedd.
Gerardinia heterophylla Dene
Laportea crenulata Gaud.

Verbenaceae

Caryopteris Wallichiana Schau.

Vitaceae

Vitis lanata Roxb.
„ lanata glabra.
„ semicordata Wall.
„ lanceolaria Wall.

Summary.

1. In the region between 4,000 and 5,000 ft. in altitude in the part of Kumaon studied there are three forest types, the monsoon, dominated by *Bauhinia variegata*, *B. retusa* and *B. Vahlii*, the *Pinus longifolia*, and the *Quercus incana*. This altitude is the upper limit of the Bauhinia and the lower of the pine and oak formations.

2. The Bauhinia is a distinctively monsoon type almost leafless at the beginning of the rains. It is adapted to great extremes of humidity.

3. The pine forest has sparse foliage and occupies well drained slopes, crests and ridges. It is adapted to relatively low humidity and high insolation.

4. The oak forest is of the broad-leaved sclerophyllous type of Schimper. It is adapted to places with no very great extremes of temperature or humidity.

5. The pine and the *Bauhinia* are, at this altitude, pioneer forms which tend to be ultimately succeeded by the oak. At a lower altitude the *Bauhinia* is the climax type.

6. Xerophytic and hydrophytic successions include numerous pioneer grassy or shrubby stages but the whole tendency is toward the oak.

7. The influence of man is constantly causing a retrogression of the plant population toward the xerophytic, the climax forest being reapproached by a secondary succession.

8. The valley abounds in lianas, epiphytes, strangling forms and parasites.

Grateful acknowledgment is due to Dr. Winfield Dudgeon for loaning a number of the photographs used as well as for giving valuable hints in this study.

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Explanation of Plates

Fig. 4. Aspect of the Kumaon Himalayas looking eastward from about 5,000 ft. at Sat Tal. The hill in the foreground has *Pinus longifolia Roxb.* on the crest and ridge toward the observer the *Bauhinia* formation on the south (right side) and *Quercus incana Roxb.* on the north (left side). In the center of the picture is the Bhim Tal lake and village. June, 1919.

Fig. 5. Forest of *Pinus longifolia Roxb.* at 5,500 ft. near the top of the ridge northwest of Sat Tal valley. The pure character of the forest is noteworthy. The abundant seedlings beneath the larger trees are all of about the same age, have appeared after a fire has destroyed the previous crop of seedlings and have practically held the ground against invaders. May, 1919.

Fig. 6. A monsoon forest at 4,500 ft., Sat Tal, on an east-facing slope. Prevailing trees are *Bauhinia*, *Grewia* and *Nyctanthes*, the latter a relict from the pioneer stage. The trees are relatively bare and the ground covered with fallen leaves. June, 1919.

Fig. 7. A dense portion of the same formation as shown in 6. *Bauhinia Vahlii W. & A.*, the largest of lianas in this region, is shown in the middle foreground.

Fig. 8. *Quercus incana* forest. Mixed with the *Quercus* are *Rhododendron arboreum Sm.*, shown in the right foreground, and *Pieris ovalifolia D. Don.* Photograph taken near Landour but quite representative of the same forest at Sat Tal. June, 1921.

Fig. 9. Branch of *Quercus incana* during the monsoon season showing abundance of epiphytic ferns among which *Leucostegia pseudocystopteris Kunze* predominates. Landour, August, 1914.

Fig. 10. *Woodfordia-Nyctanthes* pioneer shrub formation of monsoon forest. Sat Tal, south slope, 5,000 ft., June, 1919.

Fig. 11. South-facing slope a mile north of Sat Tal valley. At the crest is *Pinus longifolia Roxb.*, in the valleys is *Quercus incana Roxb.* above and trees of the Bauhinia formation lower down, together with pioneers of both formations, at the base are terrace-edge pioneers, mostly *Rosaceae* and *Berberis asiatica Roxb.* Much of the exposed slope is the xerarch pioneer grassland formation. The north-facing slope just across the valley, is occupied by a dense and uninterrupted oak forest.

Fig. 12. A south slope, 5,000 ft., at Sat Tal, showing edaphic distribution. The valley is occupied mainly by broad-leaf evergreens, bordering which are mainly monsoon-deciduous trees, while the exposed ridge is mainly grassland. June, 1919.

Fig. 13. Successions in a stream just outside the Sat Tal valley.

Zone 1. Floating aquatics.—*Algae, Nitella, Utricularia, Hydrilla, Vallisneria, Lemna minor.*

Zone 2. Rooted aquatics.—*Typha angustata Chaub. and, Bory, Scirpus mucronatus L., Oenanthe stolonifera Wall., Polygonum* spp.

Zone 3. Marsh vegetation.—*Polygonum* spp., *Acorus Calamus L.*, and *Juncus prismatocarpus Br. Panicum paspaloides Pers.* extends horizontally through the rooted aquatic stage.

Zone 4. Wet meadow.—*Hydrocotyle asiatica L., Eleocharis congesta D. Don., Kyllingia brevifolia Rottb.*

Zone 5. *Berberis-Rosaceae* pioneer stage to oak forest. May, 1919.

Fig. 14. *Salix daphnoides Villars* in the margin of Bhim Tal lake. Adventitious roots have developed just beneath the high water mark. The water is now at its lowest stage. May, 1918.

Fig. 15. Terrace-edge pioneers near Sat Tal at 4,500 ft. Mainly *Berberis asiatica Roxb.* and the rosaceous shrubs, *Prinsepia utilis Royle, Crataegus crenulata Roxb.*, and *Rosa moschata Mill.* May, 1919.

Fig. 16. *Euphorpia Royleana Boiss*, a common xerarch pioneer on exposed situations. Sat Tal, 5,000 ft. June, 1919.

Fig. 17. *Heptopleurum venulosum Seem.*, a hemiepiphyte which embraces the trunks and branches of trees. Sat Tal, mainly in Bauhinia formation. May, 1919.

Fig. 18. *Viscum japonicum Thunb*, a hemiparasite, on a twig of *Quercus incana.* Sat Tal. May, 1919.

Fig. 19. *Ficus Rumphii Bl.*, a hemiepiphyte, one of the "strangling figs", with a network of roots embracing a tree trunk. This plant often strangles and displaces the tree on which it grows. Below Sat Tal, 3,000 ft. May, 1919.

Fig. 20. Epiphytic orchids on a branch of *Nyctanthes arbortristis, L.* Monsoon forest, Sat Tal. May, 1921.

Fig. 21. *Curcuma angustifolia Roxb.*, a scitaminaceous herb of the early monsoon season, growing from a fleshy rootstalk. Monsoon forest, Sat Tal, 4,500 ft. June, 1919.



FIG. 4.

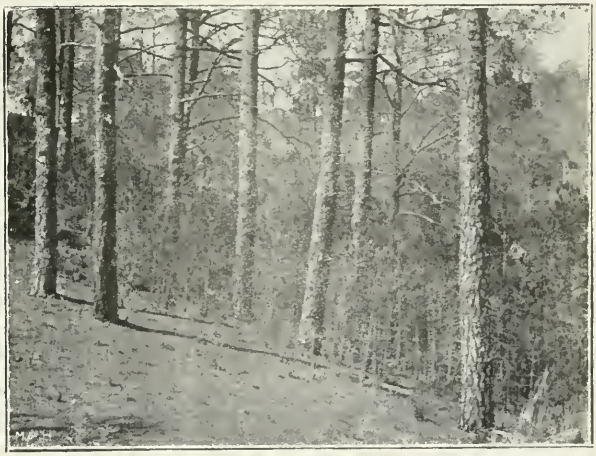


FIG. 5.

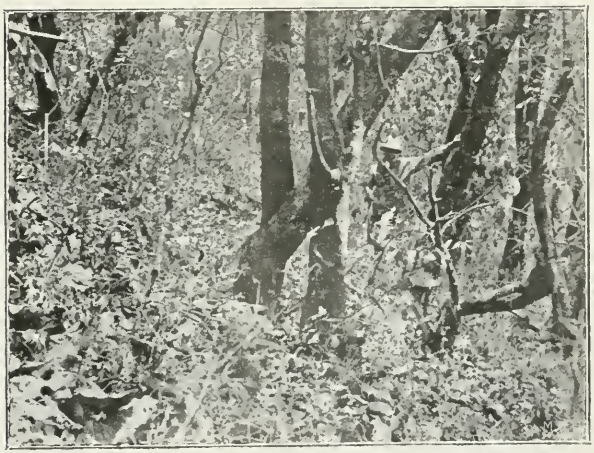


FIG. 6.

FIG. 7.

FIG. 8.

FIG. 9.



FIG. 10.

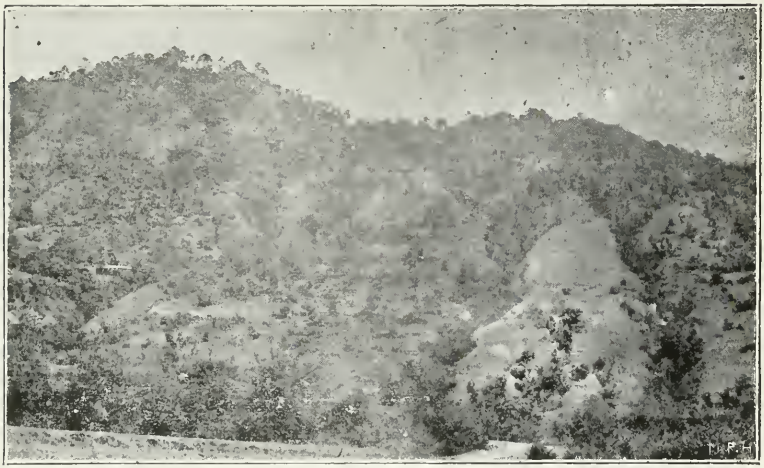


FIG. 11.

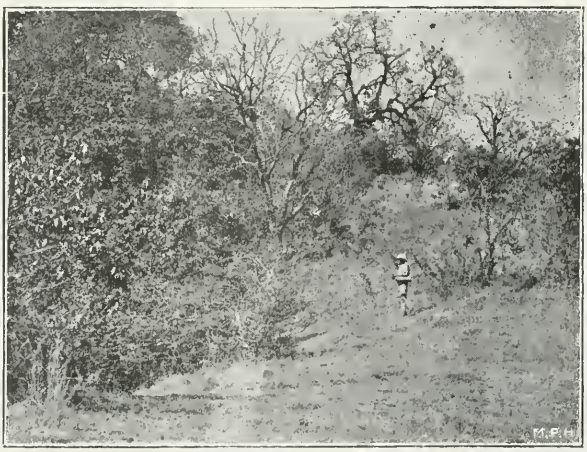


FIG. 12.



FIG. 13.



FIG. 14.



FIG. 15.

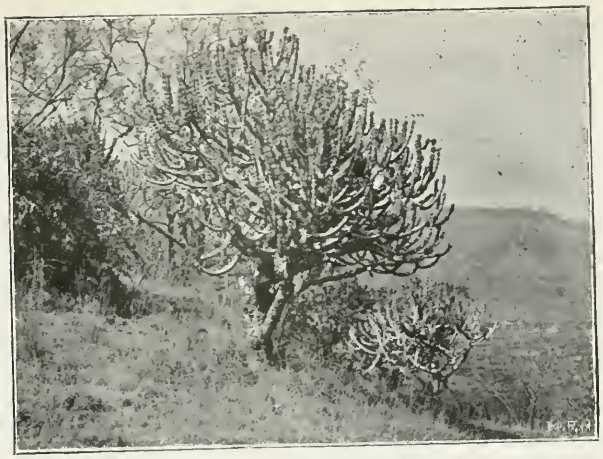


FIG. 16.



FIG. 17.



FIG. 18.



FIG. 19.

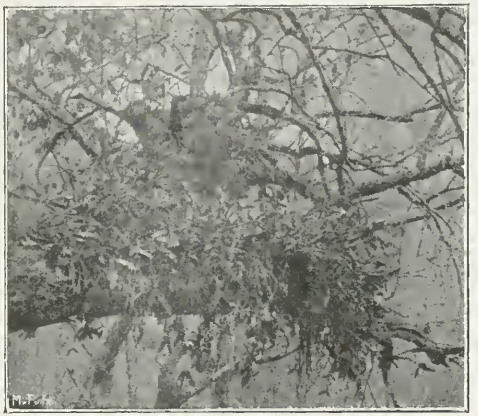


FIG. 20.



FIG. 21.

THE INDIAN SPECIES OF ERIOCAULON

By P. F. Fyson, M.A., F.L.S.,
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(*Continued from p. 207.*)

20. **E. Dianae** Fyson, sp. nov. (Fyson. No. 3819 at Rudrasiri) Caulis perbrevis. Folia lanceolata, 3-7 cm. longa, 4-6 mm. lata, plana, glabra. Pedunculi complures, 7-15 cm. aut longiores, glabra. Capitula 5-8 c.m. hemi-spherica ; bractae involucrantes stramineæ and glabrae, quam capitulo longiores aut æquantes, aut demum reflexae. Bractae flores superantes obovato-cuneatae, summo-dorse puberulae, viridi nigrescentes. Flores trimeri. Flos ♂ : sepala in spatham antica fissam, connata, antheræ nigræ. Flos ♀ : sepala inaequalia, duo navicularia dorso puberula, unum planum, lanceolatum aut linearium, et quam ceteris brevius. Plate 11.

Peninsular India ; Western Ghats from Mt. Abu and Bombay to Calicut.

I include in this species a large number of forms the extremes of which are sufficiently distinct to be considered good species, were it not for the intermediates which grade into each other, for even the 7 varieties given below are not easily separated.

* Bractae involucrantes quam capitulo longiores.

† ♀ floris tertius sepalum planum, oblanceolatum.

Var. *a typica.* Bractae involucrantes quam capitulo longiores, femini floris tertium sepalum planum. Plate 12.

Salsette to S. Kanara.

A beautiful little plant, the tips of the involucral bracts showing beyond the margin of the head when seen from above. The head itself may be nearly flat, hemispherical, globose, or even ovoid taller than broad, depending apparently on local conditions. The third female sepal is flat but not much shorter than the others and not linear as in the other varieties. The larger heads can be distinguished only by the female sepals (the two larger being much more boat-shaped and the third flat) from *E. quinquangulare* L.

†† ♀ floris tertius sepalum linearium

Var. *b longi-bracteata.* Bractae involucrantes quam capitulo multo longiores ; floris sepalum tertius latum aut linearium. Calicut. Plate 13.

Leaves 2-2½ in. by ⅛ in. and scapes about twice as long. Heads ¼ in. diam. with bracts spreading below over ½ in. across in all.

Corresponds to var *martiana* of *E. quinquangulare* and might be considered that plant with one sepal smaller and flat.

* * Bractae involucrantes quam capitulo nec longiores.

Var. *c parviflora*. Bractae involucrantes capitulo aequantes ; floris tertius sepalum planum aut linearium.

Coorg and N. Kanara.

The head has no rays, the bracts being short, and the flowers are much smaller than in var. *a* and *b*. Possibly a poor form of var. *a* but apparently distinct.

Var. *d Richardiana*. Planta robustior ; pedunculi 20-25 cm. ; folia 15-20 cm. ; capitula globosa ; bractae involucrantes breviores, reflexae. Ptate 14.

S. Kanara.

A robust plant with globose unrayed heads. Stem $\frac{1}{4}$ in. thick and $\frac{1}{2}$ in. long. Scapes up to 14 inches very slightly pubescent in the most robust specimens. The third female sepal much shorter than the others and linear. Seeds oblong light yellow.

Var. *c* Folia quam var *a* etc. angustiora, etiam linearia ; capitula globosa, alba aut nigrescentia ; bractae reflexae.

Hills near Bombay.

Leaves acicular. Heads small, globose with reflexed bracts. connects var. *a* to the next.

Var. *f triloboides*. Capitula nigra aut nigrescentia globosa. Plate 15.

Khandala to Wynaad.

Leaves as in var. *a* Heads globose, dark almost black, distinguishable only by the third female sepal being linear from *E. trilobum* Ham. This variety has in consequence frequently been identified as that species. See p. 139, fig. 3 which is of this plant, but wrongly named *E. trilobum* on p. 150, also see p. 206.

Var. *g conica*. Capitula conica, basi truncata, folia linearia.

Mysore to Wyanaad,

Heads conical with horizontal base, very black, because nearly glabrous : clearly connected with var. *f*. This plant is possibly *E. Rouscianum* Steud ; see Appendix I.

21. **E. Sedgwickii** Fyson sp. nov. (Sedgwick Nos. 4548 !) 4572 ! 4671 ! 4648 ; 4847 ; 4837 ; in Herb. Pres. Coll. Madras.

Caulis perbrevis. Folia tenuia, 7-15 cm. longa, 3-5mm. lata, perpauca (?) glabra. Pedunculi 10-20 cm. glabra. Capitula globosa, nivea, valde pilosa. Bractae involucrantes nigrae, bractis flores superantibus rhombeo-cuneatae, sed albis pilis dense villosis. Receptaculum, dense-villosum. Flos ♂ ; sepala 2, angusta ; petala 3,

aequalia, glandulis magnis instructa, antherae nigrae. Flos ♀ sepala 2, angusta; petala 3, late-oblanceolata, magnis glandulis instructa. Germen tricoccum, Semina oblonga-eliptica, rubro-fusca.

Bombay, Mahabaleshwar on hill sides, on rocks, etc. Plate 16.

Remarkable for the very dense covering of white hairs on the floral bracts making the heads snow-white; and for the broad female petals and their large glands.

In general appearance and in the broad female petals the plants are often very like plants of *E. horsley-kundae* Fyson, Var *megalocephala*, No. 47, collected by Talbot and Meebold from the Bababoodans to the Nilgiris. The female petals are like also those of *E. Geoffreyi*, *E. Collettii*, etc. where however the receptacle is glabrous. I cannot find anything in Ruhland's monograph to correspond with this and therefore suggest a new species.

III. HIRSUTAE.

Stem disciform. Leaves scapes and especially the involucral bracts hairy, rarely glabrous. Receptacle hairy. Flowers both male and female normal, (p. 148) but petals in some unequal.

About 5 species (10 in Ruhland l.c.) in India and Burma with extensions to China and Malaya possibly two in Africa.

TABLE SHOWING RELATIONSHIP AND DISTRIBUTION.

—Brownianum ...
- China.
- Var macrophyllum...S. Burma and Straits Settlements.
- Type.....Khasia and N. Burma.
- Var nilagirense.....S. India and Ceylon.

—Rhodae.....Wynaad and S. W. Mysore.

—robusto-brownianum.....Western Mysore.

——gracile.....and Var Kurzii.....Burma.

—Wightianum.....Burma.
- Var Helferi.....Andamans.

—lanceolatum.....S. India on West Coast.

Key to the Hirsutae.

* Bracts of the involucre black, or brownish at the base. Heads 1/3-1 inch diam.

Floral bracts acuminate, hairy, giving the head an echinate appearance (W. Ghats). 23 robusto-brownianum.

Floral bracts dirty white, nearly glabrous. (W. Ghats. of Mysore and Wynaad). 25 E. Rhodae.

Floral bracts black, hairy acute. (Khasia and North Burma, S. India Mountains, Malay and China) ... 22 E. Brownianum.

** Bracts of the involucre pale, straw-coloured when dry.

Scapes to 20 in.; heads 1/2 in.; female sepals unequal, visible beyond the floral bracts. (Malabar) ... 27 E. lanceolatum.

Scapes 6-10 in.; heads $\frac{1}{4}$ to $\frac{3}{4}$ in.; female petals clawed; floral bracts white, outer nearly glabrous. (Burma and Andamans) ... 26 E. Wightianum.

Scapes 8-12 in.; female petals oblanceolate, without glands; floral bracts blackish... 24 E. gracile.

22. **E. Brownianum** Mart. (Wall. Cat. 6066 in Herb. Calc !); F.B.I. vi, 576, No. 18; Ruhl. No. 117 and E. nilagirense No. 93. Leaves narrow about $\frac{1}{4}$ in. wide and 15-20 in. long, glabrous or hairy, as also the scapes which are about as long. Heads 1/3—1/2 in. Involucre pale, glabrous or hairy. Female flower-Sepals dark, deeply boat-shaped. scabrid on the keel. Petals narrow, with long hairs and large glands Seeds oval, dark brown. Plate 17.

Var. *a typica* leaves and involucre often (but not always) glabrous, Assam; Silhet (type), Khasia; Burma; Manipur.

Var. *b nilagirense* Steud. Whole plant hairy and more robust than the type. Leaves usually shorter and broader, but sometimes narrow. Scapes stout and hairy. Heads 1 inch flat or hemispheric. Involucre black, hairy. Female flower:—Sepals less deeply boatshaped Petals a little broader; otherwise as in the type. See Fig. p. 263.

S. India and Ceylon at high elevations.

Very common in semi-dry or marshy land at about 7000 ft., forming usually dense tufts a foot or more across. The flowers smell strongly of honey and are visited by small butterflies. The name suggests that this is a variety confined to these regions, but in Herb. Calcutta are sheets from Khasia hardly if at all different. Hooker was the first I think to reduce Steudel's species to E. Brownianum Mart. Koerniche considered it closest to E. Wightianum.

Var. *c macrophyllum* Ruhl. lc. No. 95.

Malay Peninsula.

Var. *b* was founded by Steudel as a distinct species, but reduced by Hooker to E. Brownianum. It was restored to specific rank by Ruhland and because the type has glabrous involucre is separated in his clavis by 24 species.



ERIOCAULON BROWNIANUM *Mart.*
Var. *nilagirense.*

Ruhland described (lc. p. 77) the Malay Peninsula form (var. *c*) as a distinct species *E. macrophyllum* (Ruhl. No. 95) but if the sheet so named in Herb. Calc. is identified correctly it is in my opinion the same species. In Herb. Calc. is a sheet from China which might equally well be separated as a distinct species.

23. **E. robusto-brownianum** Ruhl. (Law in Canara, Dharwar and Bellary in Herb. Calc. !) ; Ruhl No. 96. Size and habit of the last species but leaves half as long as the scapes. Floral bracts acuminate, very white because covered with thick white hairs, giving the head a white echinulate appearance. Female petals hairy, narrow at the base, with large glands. Plate 18.

Peninsular India, Western Mysore and Kanara.

A very striking plant because of the white acuminate floral bracts. There are no sheets exactly like it from Burma of the Malay, but the species re-appears in Yuman (Dr. Henry) in a smaller form. Wall. Cat. 6967 B, described by me in Kew Bulletin 1914 as *E. mysorense* sp. nov. is I think this species. I had not then seen Ruhland's type quoted above, but I have not seen Wallich's sheet again to compare with the type.

24. **E. gracile** Mart. (Wall. Cat. 6079 in Herb. Calc. !) ; F. B. I. vi 577, No. 19, under *E. sericans* ; Ruhl. No. 98.

Annual (*Mart*). Leaves $\frac{1}{2}$-$1\frac{1}{4}$ by $\frac{1}{8}$ in., tapering to the acute apex. Scapes 8-12 in. glabrous, very slender. Heads $\frac{1}{4}$ in. globose snow-white. Involucre pale yellow, pubescent. Floral bracts, acute or cuspidate, darkish, pubescent. Female flower :—Sepals boat-shaped, narrow. Petals, nearly glabrous, broadly oblanceolate without glands, unequal, longer than the sepals. Male flower normal. Plate 19.

Burma; Prome, on the banks of the Irrawaddy (*Mart*).

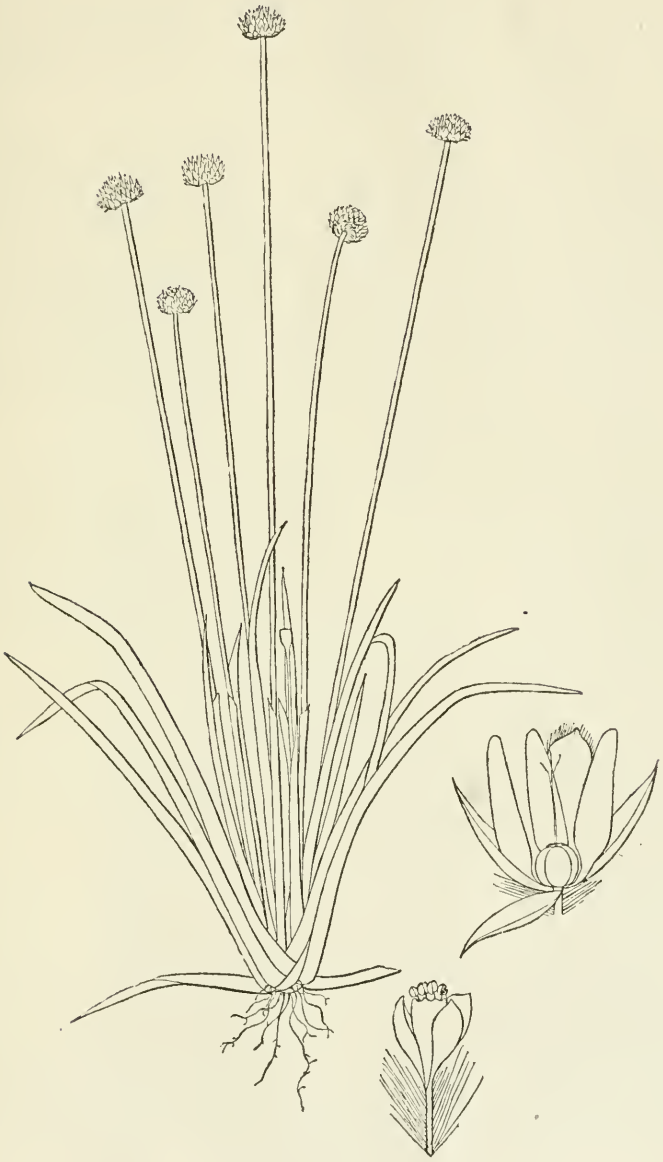
There is a second sheet Wall Cat. 6082 in Herb. Calc. very similar in external appearance, but the female petals larger and more unequal. Ruhland said this species is not the same as *E. sericans* Mart. and that the latter is *E. Wightianum* Mart. as also did Koerniche.

Var *Kurzii*. Kurz. 2638 in Herb. Calc. ! Plate. 20.

Stem and leaves as in *E. gracile* typica. Scapes about 5 in. glabrous. Heads $\frac{1}{4}$ in. hemispheric. Involucre horiz ontal bracts oblong, projecting well beyond the margin, pale, glabrous. Floral bracts shortly cuspidate, pubescent. Female sepals short and narrow. Female petals unequal, one much the largest and projecting beyond the bracts, glands small. Seeds reddish, broadly oval.

Burma, Rangoon.

25. **E. Rhodae** Fyson, sp. nov. (Fyson 9696 in Herb. Madras) Caulis perbrevis. Folia iisdem sp. E. nilagirense similes Pedunculi plures 15-30 cm. Capitula globosa 1.2-2 cm. Bractae involucrantes reflexae. Bractarum flores superantium inferiores albae, acutae ;



D. R. Fyson del. ERIOCAULON RHODÆ *Fyson.*

superiores quomodo nigrescentes, dorso pubescentes. Receptaculum villosum. Flores trimeres flos ♀ longi-pedicillata, sepala æqualia, navicularia, alba, glabra; petala magna, lanceolata, sub-spongiosa, dorso sparsepilosa. Semen rubrum, glabrum. Flos ♂ o breviter pedicellata; antherae nigrae. (See Fig. p. 265).

Peninsular India; Mysore and Wynaad in water.

Remarkable for the white sepals and bracts and for the stalked petals as in *E. lanceolatum*. Also for the long pedicels of the flowers, especially of the female which are often stalked beyond the male recalling but in reverse, the arrangement of spkelets in *Andropogon*. The scarious floral bracts, very nearly glabrous, distinguish the plant in the field from the other species of the group. In the herbarium the plants are characterised by untidy-looking heads, in great contrast to the very firm neat echinulate heads, of *E. robusto-brownianum*, which occurs in the same localities.

26. **E. Wightianum** Mart.; F. B. I. vi 576, No. 17 in part; Ruhl. No. 92. Perennial (*Mart.*) Scapes 6-10 in. Leaves half as long, by ½-¾ in., slightly hairy; as also the scapes. Heads ½ in., globular lby the reflexed involucre, snow white, with white floral bracts, the ower of which are nearly glabrous. Female petals ovate lanceolate distinctly clawed, with small or no gland, and spongey. Plate 21.

Burma. Moulmein etc, Tavoy.

Hooker in F.B.I. l.c. included the Peninsular plant, *E. robusto-brownianum* Ruhl. in this species.

Var. *Helferi* Hook. f, (Helfer 1584 in Herb. Calc.!) F.B.I. vi, 583 No. 38, Ruhl. lc. A much smaller plant. Scapes 5-8 in., slender. Leaves 2-3 by ¼ in., acute. Heads ¼ in. Female petals shorter and broader that in the type. Plate 22.

Andamans.

Founded as a distinct species by Hooker but certainly a geographical form and reduced as such by Ruhland.

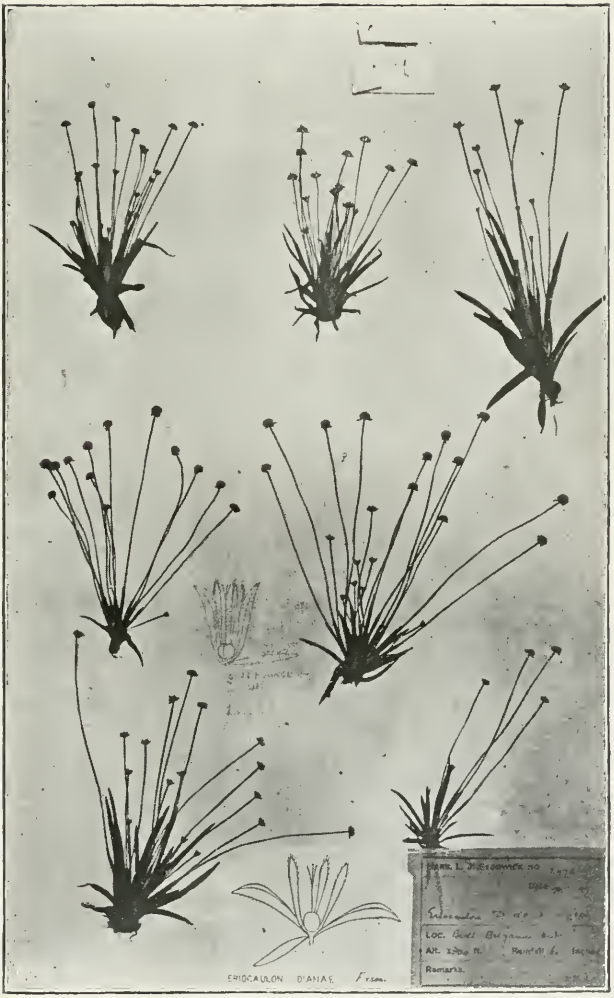
27. **E. lanceolatum** Miq.; F.B.I. vi 577, No. 20; Ruhl, No. 99. Scapes slender 5-6 in. hairy. Leaves 2½ cm. by ¼ in. at the widest, acute, nearly or quite glabrous. Heads ¼ in., white. Floral bracts short, darkish, obcuneate, but overtopped by the female sepals which are longer and visible beyond them. Female petals shorter or longer than the sepals, oblanceolate, often or always unequal in length. Seeds dark brown, oval. Plate 23.

Western Peninsular on the Malabar Coast.

Remarkable for the glabrous conspicuous sepals.

(*To be Continued*).

INDIAN SPECIES OF ERIOCAULON, Pl. 11.



ERIOCAULON DIANAE *Fyson.*



ERIOCAULON DIANAE *Fyson.*
Var. *typica.*



ERIOCAULON DIANAE *Fyson.*
Var. *longibracteata*

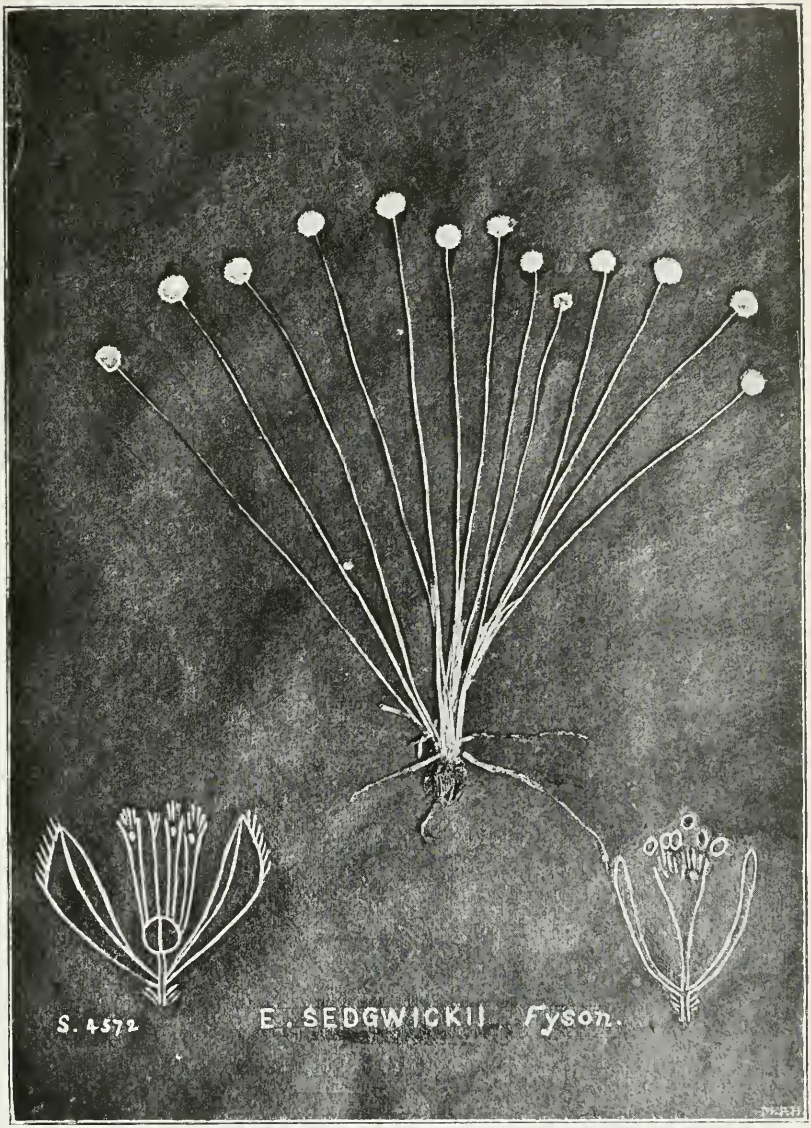
INDIAN SPECIES OF ERIOCAULON, Pl. 14.



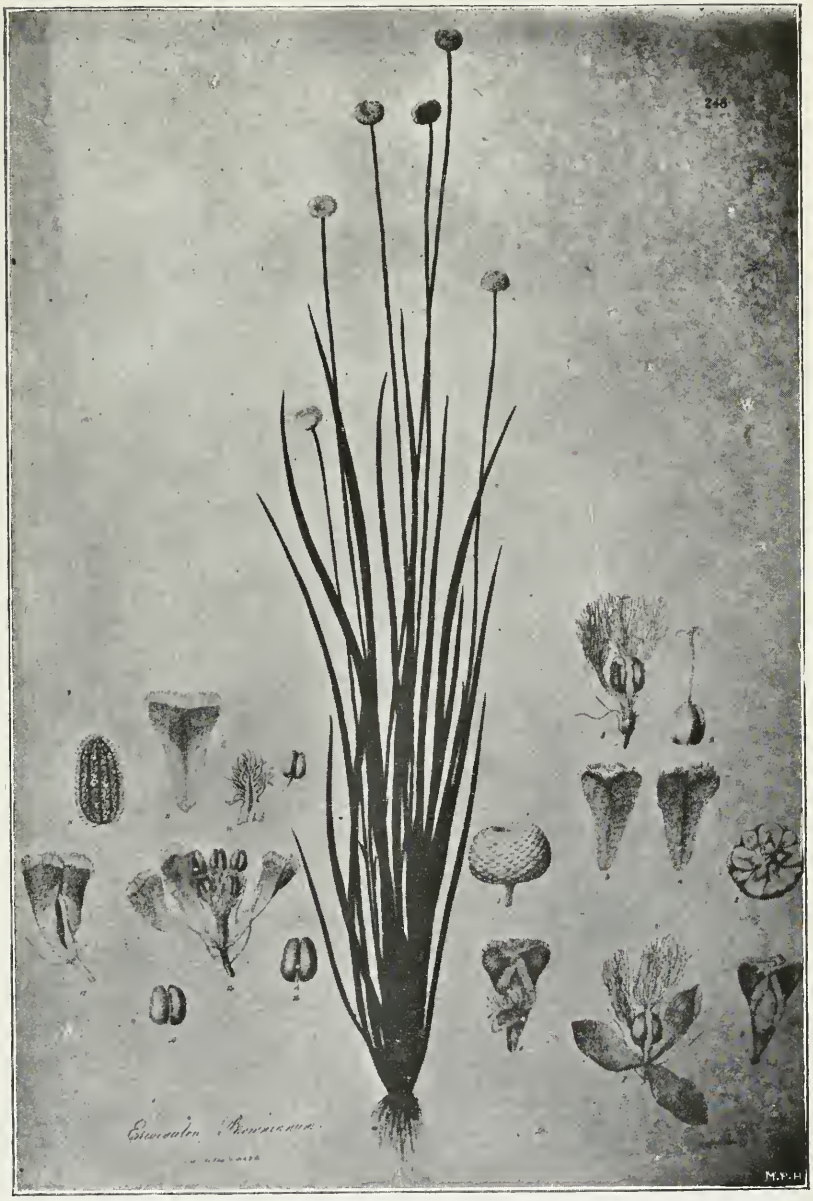
ERIOCAULON DIANAE *Fyson*
Var. *Richardiana*



ERIOCAULON DIANAE *Fyson.*
Var. *triloboides.*

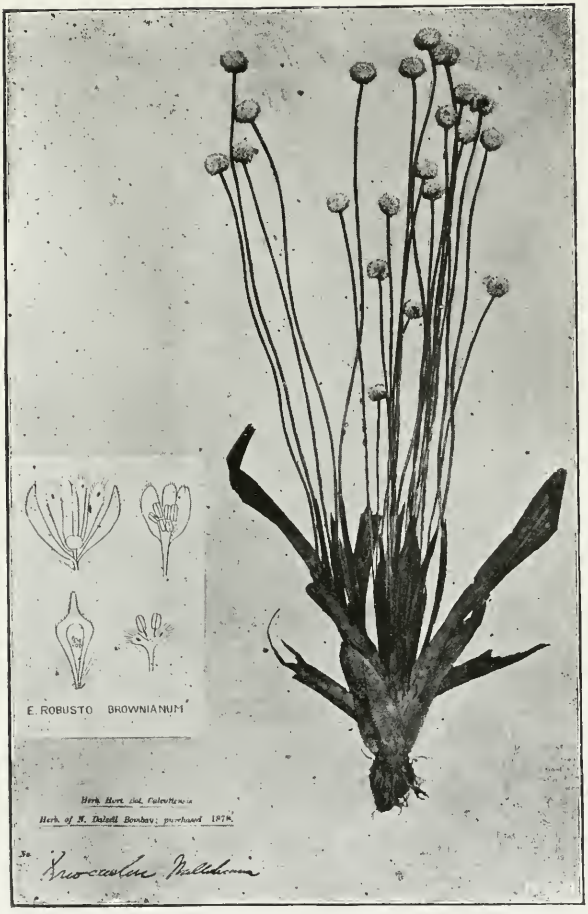


ERIOCAULON SEDGWICKII *Fyson.*

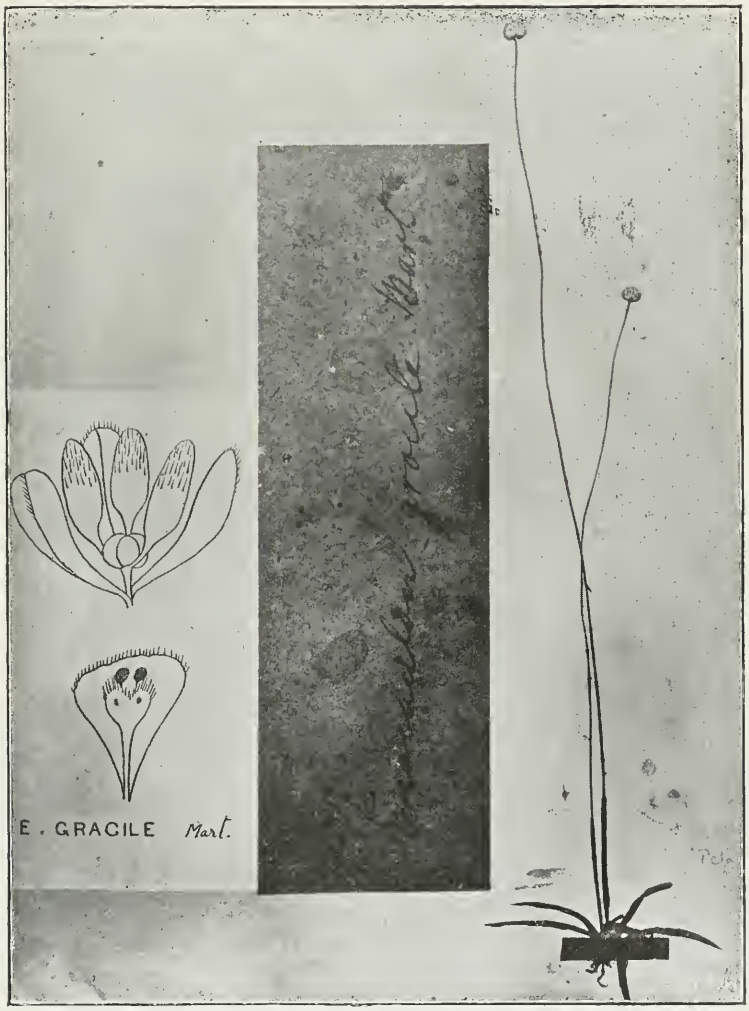


ERIOCAULON BROWNIANUM *Mart.*

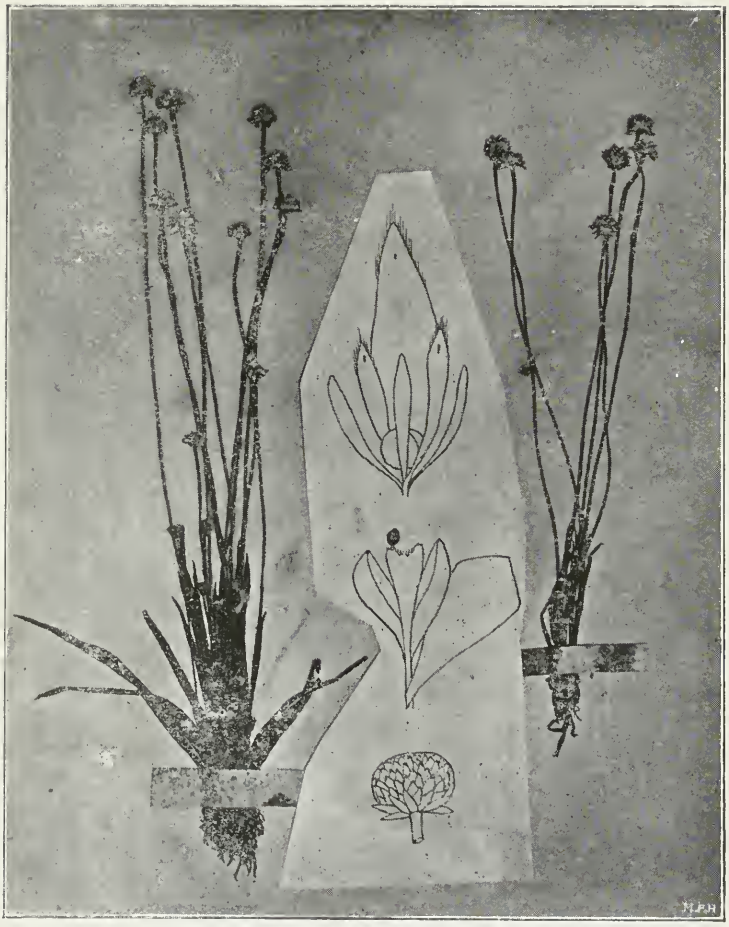
From a photograph of plate in Wallich's Plant. Rari. Asiaticae, Vol. III.



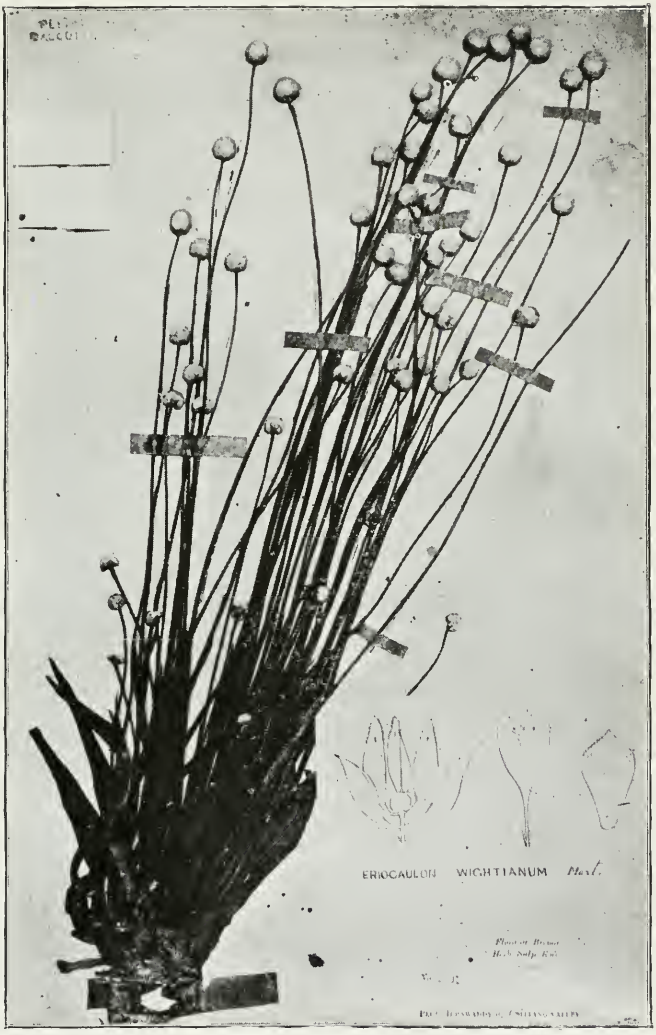
ERIOCAULON ROBUSTO-BROWNIANUM *Ruhl.*



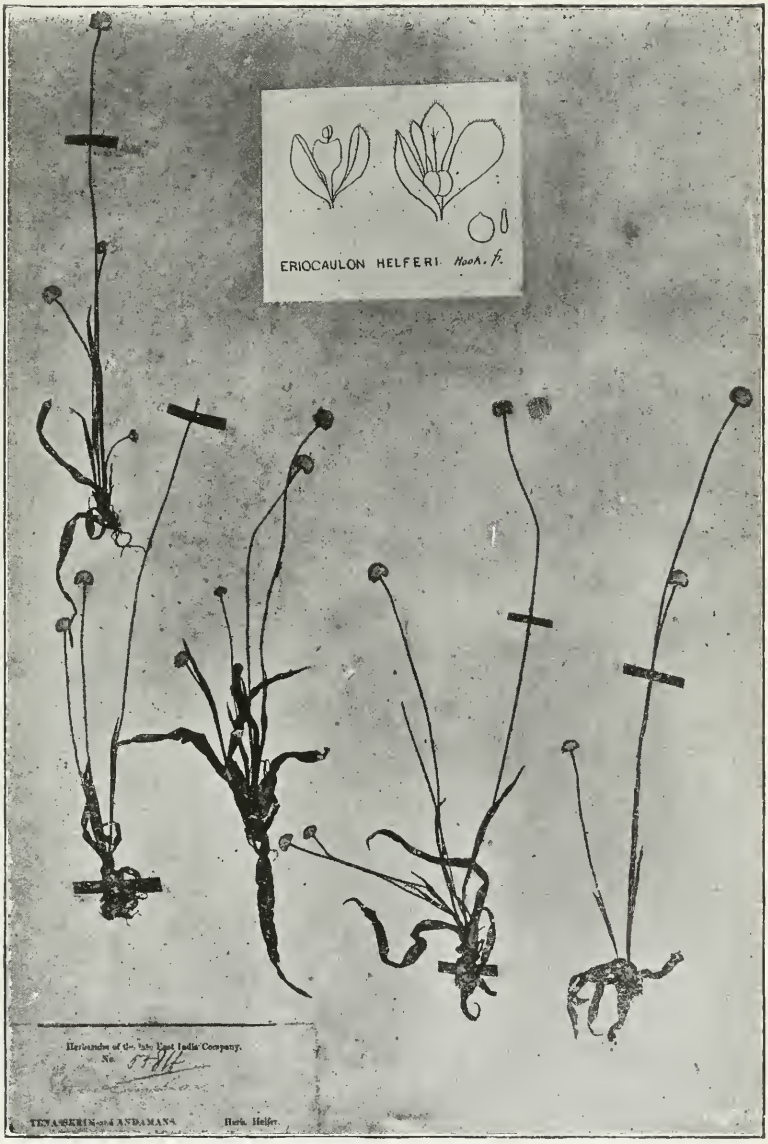
ERIOCAULON GRACILE *Mart.*



ERIOCAULON GRACILE *Mart.*
Var. *Kurzii.*



ERIOCAULON WIGHTIANUM *Mart.*
The third sepal is not shown in the female flower.



ERIOCAULON WIGHTIANUM *Mart.*
Var. *Helferi.*



ERIOCAULON LANCEOLATUM *Miq.*

CURRENT LITERATURE.

Fungi

Buller A. H., The Ocellus Function of the Sub-sporangial Swelling of Pilobolus--*A paper read before the Linnæan Soc. of London. The following is taken from the published minutes.*

He stated that the subsporangial swelling of *Pilobolus* functions, not merely as part of a squirting apparatus, *but also as an ocellus*, which receives the heliotropic stimulus which causes the stipe to turn the fungus gun toward the light. The swelling is transparent and refracts light, like the bulb of a Florence flask filled with water. Its diameter is always greater than that of the black sporangium which it supports.

The sporangiophore of *Pilobolus* appears to be the only orthoheliotropic plant organ known which takes up its positively heliotropic position owing to the possession of a special light-perceiving cell-structure.

Pilobolus may well be described as a fungus with an optical sense-organ or simple eye; and, in using its eye for laying its gun, it appears to be unique in the plant world.

The paper was illustrated with models. A fuller account of the *Pilobolus* eye is about to appear in the 'Transactions of the British Mycological Society.'

Cytology

Guilliermond, A. Les constituants morphologiques du cytoplasme d'après les recherches récentes de cytologie végétale. (Morphological constituents of cytoplasm). *Bull. Biologique 54 : 465-512. 24 figs. 1921.*

This paper is a summary of our present knowledge of the structures in the cell outside the nucleus, to which the author has devoted many years of study. These structures are considered under three heads : (1) the chondriome ; (2) microsomes ; and (3) the vacuole system.

Chondriome is a convenient term for the ensemble of mitochondria in the cell. After proper fixation and staining the mitochondria are revealed as a large number of minute granules, chains of granules, or filaments of varying length, scattered through the cytoplasm. They are found in all cells of all plants (except Cyanophyceae and Bacteria) and animals, and are permanent cell organs, arising always by division of pre-existing mitochondria. They are destroyed by the usual fixing agents containing alcohol and acetic acid, which explains the fact that they were not discovered till as late as 1894 ; chromic acid, osmic acid, and formalin preserve them faithfully. They stain vividly with iron-haematoxylin, acid fuchsin, and crystal violet. A few cases are known where they may be observed in the living state, as in the epidermal cells of the perianth of white tulip, the leaf cells of Iris germanica, and in the filaments of a species of Saprolegnia.

In plants, some of the mitcchondria remain "inactive," that is, retain permanently their original form, while others develop into (1) amyloplasts, (2) chromoplasts, and (3) chloroplasts. This fact has led many investigators to conclude that the primordia of plastids are really not mitochondria at all, but are structures of an entirely different order. Such a view finds its strongest support in Cryptogams having one or few large chloroplasts, as in Conjugatae, Anthoceros, and Selaginella; here the primordia of plastids are distinguished by their larger size, even in the youngest cells of the growing points. Guilliermond is convinced that such a distinction should not be made, because the staining and other reactions of plastid primordia are exactly those of "inactive" mitochondria, and even the size distinction disappears in Phanerogams and in fungi. He thinks that the most that can be said is that there are two kinds of mitochondria in the plant cell.

The function of "inactive" mitochondria is not known, though in animals where no other kind exists, they are believed by some authors to elaborate secretions and certain pigments, to play a part in oxidations, and to function in some way in heredity. Probably they have similar functions in plants.

Microsomes are more or less transient, minute, fat-like granules, variable in number, and distinguished in various ways from mitochondria. Nothing beyond the fact of their existence is mentioned; it is not even known whether they are of general occurrence in plant cells.

The vacuole system is a constant feature of plant cells, and arises in young cells from "vacuole primordia" lying close to the nucleus. These primordia so closely resemble mitochondria in appearance that some cytologists hold that they actually are mitochondria. They possess about the same fixing and staining reactions, but are distinguished in various ways. The author believes that absolutely no relation exists between the vacuole system and the mitochondria——that they are two quite independent systems superposed on each other in the cell. The primordia enlarge as the cell grows, they anastomose to form a network, and portions swell up to become the familiar vacuole system. The process of growth appears to be the result of hydration of the original substance of the primordia. The vacuoles probably are centres of elaboration of various substances, *e.g.*, anthocyanins.

The paper is fully illustrated by figures from various authors, and a complete bibliography is given; one is struck by the preponderance of papers in French. The author very skillfully emphasizes the deficiencies in our knowledge of cell morphology, and shows the need for an immense amount of the most detailed and painstaking investigation.

WINFIELD DUDGEON.

Physiology

Hahn, Glenn G., Hartley, Carl and Rhoades, Arthur S. Hypertrophied Lenticels on the Roots of Conifers and their Relation to Moisture and Aeration. *Jour. Ag. Res. 20*; *253—265, 1920.*

The authors observed warty excrescences on the roots of conifers, particularly Pinus ponderosa, as they were dug for shipment from a nursery in Nebraska. Microscopic examination reveals the fact that they are enlarged lenticels. Further search revealed such growths on the roots of twenty-one

species of conifers in various localities, but particularly in swampy places or under conditions of extreme humidity. Heavy irrigation was found to induce such lenticels as was also the pruning of the shoots.

The literature on hypertrophied lenticels is briefly reviewed. Schenk attributes the phenomenon to oxygen hunger. Later writers think it to be caused by humidity, moist air allowing the continued formation of aerenchyma while dry air induces suberization and cork formation. De Vaux thinks humidity increases lenticellular development entirely through increase of sap pressure. Soraurer connects them with general pathological conditions of the tree. The authors are inclined to go back to the older theory that oxygen hunger is the main predisposing cause. They feel, however, that other factors contribute to the result, and suggest that the problem can be best attacked by experiments in which oxygen, carbon dioxide and water supplies in the soil are independently controlled.

L.G.K.

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All matter for the printer should be typed and on one side of the paper only. The name of a genus should begin with a capital letter, but that of the species only when it is adapted from a proper name. No comma should be put in after the specific name and before that of the founder of the species. The Editor will see to the type.

Illustrations in line should be drawn in India ink on smooth paper or card, and will reproduce best if at least twice as large as they will appear in the Journal. Photographs for reproduction by half-tone process must be on glossy paper and should be strong bright prints. Good results cannot be obtained from over-exposed negatives or weak prints.

Abstracts of papers in other Journals should begin with the author's name and initial, followed by the title of his paper and where it is published: the abstract itself beginning a new line.

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VOL. II. OCTOBER, 1921. No. 10.

THE PHYSIOLOGICAL ANATOMY OF THE PLANTS OF THE INDIAN DESERT

BY

T. S. SABNIS, B.A., M.Sc.,

St. Xavier's College, Bombay.

(*Continued from p. 227*).

GRAMINEAE—(*Contd.*)

Pappophorum elegans *Nees.*—Figs. 351, 352. Grooves deeper on the lower surface. Margins pointed and with small stereome bundles. Hairs spiny, long and unicellular. Numerous long unicellular hairs on the axis. Stomata more numerous on the lower surface. Palisade cells forming arcs on sides of veins. Veins vertically transcurrent and provided with complete bundle sheaths. Articulation tissue on the upper side of mesophyll, and extensive. Mechanical tissue in the leaf forming I-girders. Assimilatory tissue in the axis and palisade cells along smaller vascular bundles and chlorenchymatous between them. A continuous layer of sheath-cells on the inner side of the assimilatory tissue. Mechanical tissue in the axis in the form of a stereome tube supplemented by isolated sub-epidermal girders and I-girders. Webs formed by mixed small vascular bundles. Larger vascular bundles few and mostly apposed to the inner side of stereome tube. Medullary tissue of thin-walled cells.

Eragrostis interrupta *Beauv.*—Figs. 353, 354, 355. Grooves on either surface not deep. Margins pointed and with small stereome bundles. Hairs spiny. Stomata more numerous on the upper surface. Articulation tissue in the upper half of the mesophyll. Palisade cells forming arcs on sides of veins. Veins vertically transcurrent. Smaller veins apposed to lower epidermis. Bundle-sheaths complete round smaller veins and in the form of arcs on sides of larger veins. Mechanical tissue in the leaf in the form of I-girders alternating with

isolated sub-epidermal girders on the upper side. Assimilatory tissue of arcs of palisade cells on the outer side of smaller vascular bundles and chlorenchymatous between them. Mechanical tissue forming a stereome tube supplemented by isolated sub-epidermal girders and I-girders. Webs formed by strips of stereome bundles. Smaller vascular bundles with arcs of palisade cells and of sheath-cells on the leptome side and with the hadrome portion embedded in stereome tube. Larger bundles numerous in the medullary tissue. Medullary tissue formed of thin-walled cells.

Eragrostis pilosa *Beauv.*—Fig. 356. Grooves not deep, Margins pointed and with small stereome bundles. Hairs spiny and more numerous on the lower surface. Stomata only on the lower side. Articulation tissue confined to the plane of epidermis and formed of long horizontal strands. Palisade tissue forming arcs on sides of veins. Veins vertically transcurrent. Bundle-sheaths complete round smaller veins. Mechanical tissue in the leaf forming I-girders and in the axis forming stereome tube supplemented by isolated sub-epidermal girders. Assimilatory tissue in the axis chlorenchymatous. Smaller vascular bundles embedded in stereome tube. Larger bundles in the medullary tissue, few and enclosed in rings of stereome. Medullary tissue of thick-walled cells towards the periphery and of thin-walled cells towards the centre.

Desmostachya bispinata *Stapf.*—(**Eragrostis cynosuroides** *Beauv.*)—Figs. 357, 358. Grooves not deep. Hairs spiny. Stomata more numerous on the upper surface. Articulation tissue extending between two surfaces. Palisade tissue forming arcs on sides of veins. Veins with arcs of complete girders of sheath-cells. Veins vertically transcurrent. Mechanical tissue in the leaf forming I-girders and in the axis forming isolated sub-epidermal girders alternating with I-girders. Assimilatory tissue chlorenchymatous. Larger vascular bundles with arcs of stereome on the outer side. Medullary tissue of thin-walled cells.

Oropetium Thomaeum *Trin.*—Fig. 359.—Grooves deep and alternating on two surfaces. Margins pointed and with small stereome bundles. Clothing hairs unicellular. Club-shaped glandular hairs on the upper surface. Stomata more numerous on lower surface. Articulation tissue in the upper half of mesophyll and not extensive. Bundle-sheaths horse-shoe shaped and incomplete on the lower side. Palisade tissue forming arcs on sides of veins. Veins apposed to lower epidermis and vertically transcurrent above by stereome bundles. Mechanical tissue in the leaf forming isolated sub-epidermal girders on the upper side above the veins.

Structure of the Leaf.—The epidermal cells differ much in size and shape in different species as well as on two surfaces in the same species. They are either polygonal as in the greater number of species; or vertically elongated either on both the surfaces as in *C. catharticus*, *E. flagellifera* and species of *Andropogon* or only on the upper surface as in *D. sanguinalis*, *E. Royleanus* and *E. aristata*. They are extremely small in *D. bispinata* and in species of *Aristida*. The cells near the stereome bundles are very small. The outer walls are thickened and silicified. The lateral walls are thin and straight. The former are papillose in *E. aristata* (fig. 349), *C. villosa* and *O. Thomaeum*, the papillose differentiation being quite conspicuous on the upper surface in the former. The upper epidermis is usually characterised by furrows of various depths and the epidermal cells of the furrows are quite characteristic. They are vertically elongated, thin-walled, colourless and narrowed above, and they form the articulation tissue. The articulation tissue either occupies the upper half of the mesophyll, or it extends in the form of vertical strands almost to the lower surface, the lower half of the strand being formed of horizontally elongated thin-walled cells as in *C. villosa* (fig. 345), *P. elegans* (fig. 351) species of *Eleusine* (figs. 346, 349), *E. Royleanus* (fig. 323), *L. senegalensis* (fig. 325), and *D. bispinata* (fig. 357). In *E. Royleanus* (fig. 326) epidermal cells on the lower surface are characterised by distinct angular thickenings of the outer walls. The cuticle is toothed between the cells in species of *Aristida*.

The margins are curved upwards and are strengthened by stereome bundles. The margins are sharp or bluntly pointed in T. S. of the leaf-blade. The stereome bundles are larger in the latter.

Guard-cells are accompanied by subsidiary cells; they are either in the plane of the surrounding cells or elevated above that plane (figs. 347, 354). The front cavity is placed in a depression formed by outer thickened epidermal wall, the depression being very great in case of papillose outer walls of *E. aristata* (fig. 349). The stomata either occur only on the upper surface as in *E. hirsutus* or only on the lower as in *E. pilosa*, or more numerous on the upper surface as in *A. funiculata*, *P. turgidum*, *D. bispinata*, *E. interrupta* and *L. senegalensis*, or more numerous on the lower as in other members.

The palisade tissue forms arcs on sides of vertically transcurrent veins and complete girders round non-transcurrent veins. Complete girders of palisade cells are found round all the veins, whether they are vertically transcurrent or not in *D. sanguinalis* and *P. turgidum*. The palisade cells of the adjacent veins are in contact when the strands of the articulation tissue extending between the two surfaces

do not alternate with the veins. Sometimes adjacent palisade arcs or girders are connected together by transverse strands of palisade cells. In *E. hirsutus* there is an extensive tissue of thin-walled parenchymatous cells towards the upper surface on either side of the mid-rib; this tissue seems to form an articulation tissue which adds to the strength of the system of strands of the articulation tissue below the furrows.

Spongy tissue is not developed in any of the members and thus the ventilating system is quite reduced. The articulation tissue forms a characteristic feature of species of *Gramineae*; it is composed of thin-walled cells with a double function—that of collecting water and that of assisting the halves of the leaf-blade to curve upwards. The conical shape of the cells of the upper portion of the strands of the articulation tissue is especially suited to this purpose.

The veins are provided with bundle-sheaths of thick-walled green cubical cells. The bundle-sheaths form complete rings round non-transcurrent veins and arcs on the sides of vertically transcurrent veins excepting *E. aristata* in which all the vertically transcurrent veins are provided with complete sheaths. The bundle-sheaths in *O. Thomaeum* and *L. senegalensis* are horse-shoe shaped and are incomplete on the lower side. As regards the function of bundle-sheaths, they many form the means of inter-communication between the vessel and the assimilatory tissue, as well as assist the latter in photosynthesis. The veins are embedded in *D. sanguinalis* and in species of *Panicum*, while they are vertically transcurrent above and below by stereome bundles in *D. bispinata*, *C. villosa*, *G. Royleana*. The veins are apposed to the upper epidermis and are vertically transcurrent below by stereome bundles in *O. Thomaeum*. In *E. interrupta* the larger veins are vertically transcurrent above and below by stereome bundles; and the smaller veins are apposed to the upper epidermis and are vertically transcurrent below by stereome bundles. In other members the larger veins are vertically transcurrent above and below by stereome bundles except in *E. Royleanus*, *C. cathartieus* and *E. flagellifera*, where aqueous cells are found between the vascular bundles and stereome bundles on one side or both sides; the smaller bundles are embedded.

The veins either all lie in the same plane where the furrows on both the surfaces are more or less equally deep, or they are placed in two distinct planes where the furrows on the upper surface are deeper than on the lower—the veins below the furrows being situated in the lower plane. This arrangement of veins is well adapted to the curving habit of the leaf-blade.

The mechanical tissue is composed of stereome bundles on the lower side of all veins, except in cases where the veins are apposed to the lower epidermis, and of those on the upper side of vertically transcurrent and embedded veins. In the case of embedded veins the stereome bundles form I-girders the webs of which are formed by vascular bundles either unmixed as usually in vertically transcurrent veins, or mixed. The margins especially when they are bluntly pointed are strengthened by large stereome bundles.

The stereome bundles in *A. faniculata* are large and numerous and sometimes form a more or less continuous layer on the lower surface of the leaf-blade (fig. 335). The abundance of strengthening tissue on the lower surface is necessary to protect the leaf-blade against the tension produced by the curving upwards of the leaf-halves.

The stereome bundles on the upper side, supplemented by the articulation tissue, form an adequate strengthening tissue against strains of compression. The abundance of the articulation tissue assists the leaf-halves to regain their normal position. The occurrence of strengthening tissue on the upper surface, as extensive as on the lower, prevents the articulation tissue from performing its function.

The hairy covering on the leaf consists usually of short spiny unicellular clothing hairs with somewhat dilated bases. They are more numerous on the upper surface, usually arising from epidermal cells over the veins and arching over the furrows. Besides spiny hairs, there are long unicellular hairs arising from articulation cells of the epidermis on both sides in *P. elegans* (fig. 351) and *E. flagellifera* (fig. 346). In *E. Royleanus* there occur only long unicellular hairs which arise from articulation cells on the upper surface. Spiny hairs are replaced by short bluntly pointed unicellular hairs in *E. aristata* and in species of *Andropogon*. The hairy covering is not found on the axis except in a few cases. In *P. elegans* and *E. hirsutus* (fig. 330) there are numerous long unicellular hairs. Short spiny unicellular hairs arise from epidermal cells over stereome bundle in *E. flagellifera* and *G. Royleana*. The absence of a hairy covering on the axis can be accounted for by the highly thickened and silicified outer epidermal walls.

The abundance of spiny hairs is the outcome of a deficient supply of water ; and their usual position above the veins is due to localised extra nourishment. The dilated bases of the spiny hairs are capable of imbibing moisture and so the hair covering has a double function, that of imbibing moisture and that of protecting the surface against strong glare and light which accelerate transpiration.

Glandular hairs are of rare occurrence. They occur on the upper surface of the leaf-blade of *O. Thomaeum*, on the axis of *G. Roleana* (fig. 342) and on the leaf-blade and axis of *D. bispinata*. They are composed of a stalk-cell and of a club-shaped head which is divided by horizontal walls.

Structure of the axis.—The epidermal cells are small and have the outer walls greatly thickened and silicified. The stomata are accompanied by subsidiary cells. The guard-cells are elevated and the front cavity is placed in a depression formed by outer thickened epidermal walls.

The cortex is characterised by an extensive sclerenchymatous tissue with groups of the assimilatory tissue embedded in it. The assimilatory tissue, in *A. hirtiglume*, *P. turgidum*, *E. interruputa*, *E. aristata*, and *G. Royleana* is composed of groups of palisade cells which are separated from the stereome by single layers of thick-walled cubical cells containing chlorophyll and resembling bundle-sheath cells.

The palisade cells form a continuous ring in *P. elegans* and *E. hirsutus*. An assimilatory tissue is not found in *D. sanguinalis*, *E. Royleanus*, *L. senegalensis* and species of *Andropogon*. In other members the assimilatory tissue is chlorenchymatous and is not accompanied by a sheath-like layer.

The mechanical tissue in the axis is represented by a stereome tube supplemented by isolated sub-epidermal girders of variable sizes except in *P. elegans* and *E. hirsutus*. Flanges are given out from the outer side of the stereome tube at more or less regular intervals and in some cases (figs. 340, 355), they unite with supplementary sub-epidermal girders, thus bringing the two systems into contact and contributing additional strength to the whole mechanical system. In species of *Aristida* (figs. 336, 337), *Panicum* (figs. 320, 322) and of *Eleusine* (figs. 348, 350), in *P. elegans* (fig. 352), *G. Royleanus* (fig. 343) and *C. cathartica* (fig. 324) the smaller vascular bundles are embedded in the stereome strands, formed by sub-epidermal girders and by flanges of the stereome tube.

The embedded small vascular bundles are mixed with the accompanying sheaths (fig. 320) only, or with both sheaths and girders of the assimilatory tissue (figs. 340, 343, 352). In other cases where the vascular bundles are embedded they are unmixed. This sort of arrangement of the mechanical tissue is quite effective, as it forms an adequate strengthening tissue without preventing the assimilatory tissue from performing its function.

In *D. sanguinalis*, *E. Royleanus*, *L. senegalensis* and in species

of *Andropogon* there is a composite sub-epidermal stereome tube in which unmixed small vascular bundles are embedded. In *D. bispinata* there is no stereome tube and the mechanical tissue is represented by isolated sub-epidermal girders alternating with sub-epidermal I-girders.

Besides the two systems of the mechanical tissue described above, the vascular bundles in the medullary tissue are supported by arcs of stereome on the outer side in *D. bispinata* and in species of *Eleusine*, or are enclosed in rings of stereome in *E. pilosa*, *C. villosa*, *E. hirsutus*, *L. senegalensis*, *C. catharticus* and species of *Aristida*. The sclerenchyma in these cases chiefly protects the vascular bundles and is therefore of a local value; it does not add much to the strength of the mechanical tissue system.

The vascular system consists of vascular bundles of two sizes. The smaller bundles are embedded in the stereome tube, when it is developed, except in *E. hirsutus* (fig. 330) in which they are embedded in the assimilatory tissue. Of the larger vascular bundles, the peripheral ones are mostly apposed to the inner side of the stereome tube a few being embedded in it; and the rest are placed in the medullary, tissue in which they are supported by arcs or rings of stereome in some cases as already described.

The larger vascular bundles in *G. Royleana* (fig. 343) are more or less arranged in a ring and are embedded in the stereome tube. The vascular bundles of the larger type in *E. hirsutus* are numerous and traverse the whole of the medullary tissue.

The medullary tissue consists of thin-walled cells except in *E. hirsutus* and *L. senegalensis* where it consists throughout of thick-walled cells filled with granular contents. Medullary cells of *G. Royleana* are also filled with starch grains.

General Review.—The margins of leaf-blades are curved upwards. The articulation tissue is well developed; it is of epidermal origin and has a double function, that of an aqueous tissue and that of bringing about the curving movements of the leaf-halves. Leaf-blades are more or less furrowed on both the surfaces. The hairy covering is denser on the upper surface and usually consists of short, unicellular spiny hairs arising from epidermal cells above the veins and arching over the furrows. In some members there are long unicellular hairs, arising usually in the case of leaves, from articulation tissue cells. The external glands occur in *O. Thomaeum*, *G. Royleana* and *D. bispinata*; and are composed of a stalk cell and of a club-shaped head.

The stomata are depressed and are either present only on the upper surface or are more numerous on the upper surface. The guard-cells are elevated and are accompanied by subsidiary cells one on either side. The veins are numerous and are enclosed in complete or incomplete sheaths. The larger veins are vertically transcurrent above and below by stereome bundles. The assimilatory tissue in the leaf consists of complete girders of palisade cells round the smaller veins and of arcs of palisade cells on sides of the vertically transcurrent veins. The spongy tissue is altogether absent. The veins with the accompanying assimilatory tissue are sometimes separated from one another by vertical strands of articulation tissue.

The mechanical tissue in the leaf-blade occurs in the form of I-girders the webs of which are formed by mixed or unmixed vascular bundles of the veins. The margins especially when they are bluntly pointed are strengthened by large stereome bundles. The epidermis of the axis consists of small cells with the outer walls greatly thickened and silicified. The assimilatory tissue consists of palisade tissue or of chlorenchyma ; it is absent in some members. The mechanical tissue is represented by a stereome tube supplemented by isolated sub-epidermal girders.

Vascular bundles are of two sizes, the smaller ones being usually embedded in stereome strands formed by the sub-epidermal girders and by flanges of the stereome tube. Of the larger vascular bundles the peripheral ones are usually apposed to the inner side of the stereome tube and the rest are scattered in the medullary tissue. The medullary tissue usually consists of thin-walled cells, which, in some members, are filled with starch grains.

FILICINAE

Actiniopteris dichotoma *Bedd.*—Figs. 360, 361. A segment of the frond :—Upper epidermis of sclerotic cells and accompanied by sub-epidermal stone tissue. Lower epidermis of small tabular cells with outer walls thickened and toothed, and with groups of stone-cells intercalated amongst them below the stele. Stomata on the lower surface and accompanied by ordinary epidermal cells. Assimilatory tissue consisting of chlorenchyma. Stele supported above and below by epidermal stone-tissue. Hairs absent.

Stipe :—Epidermal cells sclerosed except at the angular portion, and accompanied by sub-epidermal stone-tissue. Cuticle toothed. Stomata in angular portion. Assimilatory tissue consisting of chlorenchyma. Hairs long and unicellular. Stele in the centre.

Structure of the Segment.—The epidermis of the frond-segment on the upper surface (fig. 360) consists of sclerotic cells with outer walls toothed in the middle. The sclerotic epidermis is accompanied by a sub-epidermal tissue of stone-cells which have the same size and structure as those of epidermal sclerotic cells. The sub-epidermal stone-tissue stops short a little behind the margin which is curved downwards over the sporangia forming a kind of an indusium. The margin presents a filamentous structure in T. S. and is strengthened by a spiral thickening of the wall. The lower epidermis is formed of tabular cells with the outer walls thickened and cuticularised; there are groups of stone-cells intercalated amongst epidermal cells above the stele. The cuticle of lower epidermal cells is also toothed in the middle of the cells.

Structure of the Stipe.—The epidermal cells of the stipe (fig. 361) are sclerosed, except at the angular portions on the upper side. The sclerosed epidermis is further strengthened by a sub-epidermal tissue of stone-cells. The epidermis at the angular portions is formed of chlorenchymatous cells with outer walls thickened. The outer walls of the sclerosed epidermal cells are toothed in the middle of the cell. The abundant development of epidermal and sub-epidermal sclerenchyma has chiefly the function of reducing transpiration which is very vigorous in Ferns; and it is a result of the deficiency of water.

Stomata occur on the lower surface of the segment and in the angular portion of the stipe, and are accompanied by ordinary epidermal cells. The guard-cells are much elevated and the front cavity is situated above the surface.

Hairy covering is absent on the segment. On the stipe there occur long unicellular thick-walled hairs strengthened in the basal portion by the spirally thickened wall (fig. 261). The external glands are not found on the segment or on the stipe.

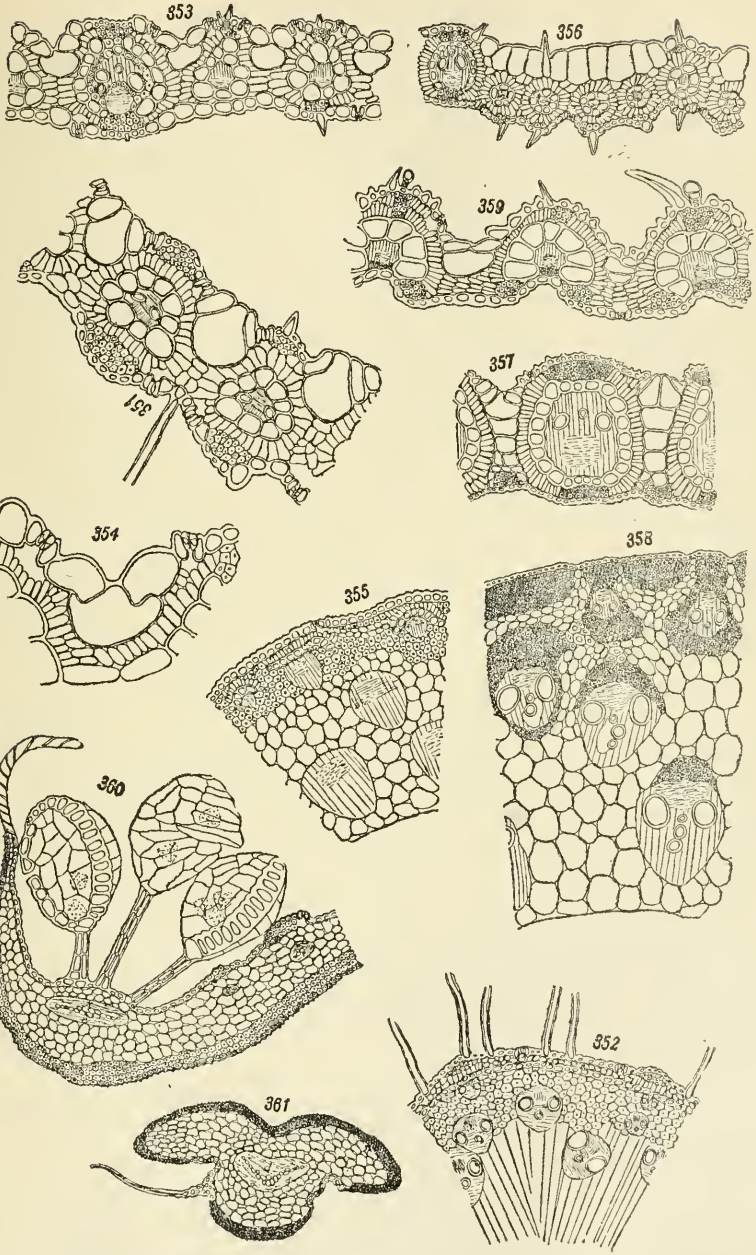
The assimilatory tissue in the segment as well as in the stipe is formed of chlorenchyma. In the stipe there are circular spaces in T. S. one near each margin.

The stele in the marginal portion from where the sporangia originate is larger than those in other portions of the pinnule. Steles, except those at the margin, are strengthened on the lower side by groups of stone-cells intercalated amongst epidermal cells (fig. 360). In the stipe there is a single larger stele in the centre.

Plate XXXVI.

351-352. *Pappophorum elegans.*
351. T. S. of the leaf.
Oc. 4 Com.; Ob. 3 mm. Ap.
352. T. S. of the axis.
Oc. 2 Com.; Ob. 3 mm. Ap.
353-355. *Eragrostis interrupta.*
353. T. S. of the leaf.
Oc. 6 Com.; Ob. 8 mm. Ap.
354. T. S. of the leaf showing stomata.
Oc. 6 Com.; Ob. 3 mm. Ap.
355. T. S. of the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.
356. *Eragrostis pilosa.*
T. S. of the leaf.
Oc. 2 Com.; Ob. 3 mm. Ap.
357-358. *Desmostachya bispinata.*
357. T. S. of the leaf.
Oc. 2 Com.; Ob. 3 mm. Ap.
358. T. S. of the axis.
Oc. 4 Com.; Ob. 8 mm. Ap.
359. *Oropetium Thomaeum.*
T. S. of the leaf.
Oc. 4 Com.; Ob. 3 mm. Ap.
360-361. *Actiniopteris dichotoma.*
360. T. S. of the frond.
Oc. 4 Com.; Ob. 8 mm. Ap.
361. T. S. of the Rachis.
Oc. 2 Com.; Ob. 8 mm. Ap.

N.B.—To get the original dimensions multiply by 1·7.



T. S. Sabnis del. PLATE XXXVI.

CONCLUDING REMARKS.

Epidermis.—As a general rule, the epidermal cells on the upper surface of the leaves are larger than those on the lower and epidermis of the axis in the same species consists of much smaller cells than those of the leaves. The epidermal cells are generally tabular with outer walls convexly arched outwards. The outer walls are flat in *Menispermaceae*, *Commelinaceae* and *Cyperaceae*. The outer walls are thickened except in *Tamariscineae* and *Commelinaceae*, the thickening being considerable in *Capparidaceae*, *Tiliaceae*, *Onagraceae*, *Rubiaceae*, *Gentianaceae*, *Scrophulariaceae*, *Acanthaceae*, *Verbenaceae*, *Labiatae*. *Amarantaceae*, *Polygonaceae* and *Euphorbiaceae*. The outer walls when flat are generally smooth; when they are convexly arched, outwards, as is generally the case, they are (*a*) either superficially granulated in *Portulaceae*, *Zygophyllaceae*, *Ficoideae*, *Asclepiadaceae* and *Chenopodiaceae*, (*b*) or with cuticle striated in *Simarubaceae*, *Lythraceae*, *Gentianaceae*, *Convolvulaceae*, *Scrophulariaceae* and *Polygonaceae*, (*c*) or with cuticle muriculate in *Violaceae*, *Rubtaceae*, *Boraginaceae* and *Solanaceae*, (*d*) or with cuticle toothed in certain *Leguminosae*, *Ficoideae*, *Compositae*, (*f*) or with papillose differentiation in *Capparidaceae*, *Caryophyllaceae*, *Malvaceae*, *Geraniaceae*, *Moringaceae*, *Caesalpinieae*, *Euphorbiaceae* and *Gramineae*.

It should be noted that in succulent plants the outer walls are flat and that in other plants they undergo various modification. Convexity and papillose differentiation of the outer walls are chiefly useful for reflecting back the rays of light; and in the case of papillose differentiation the papillae can also retain a comparatively moist atmosphere in the interspaces between them. The thickening of the outer walls reduces the loss of water by way of transpiration which is accelerated by various climatic factors in the desert. Cuticle, roughened in various ways as described above, can absorb less light and can thus reduce the loss of water which is accelerated by the strong glare and sun light reflected from the sand. The hard excrescences on the surface of the leaf and axis are produced by the deficiency of water.

The lateral walls are either straight or undulate. The latter character is common among the desert plants and gives rigidity to the epidermis.

The inner walls are usually thin and convexly arched inwards, much more so in *Elatineae* and *Geraniaceae*, thus coming into close contact with the assimilatory tissue. They, however, undergo various modifications which are all instances of xerophytic characters. They

are thickened in *Capparidaceae* and *Euphorbiaceae*, angular in *Cyperaceae* and gelatinised in *Violaceae*, *Rhamneae* and *Sapindaceae*. The thickening of inner walls reduces the loss of water. Mucilaginous modifications of the inner walls have the property of absorbing and retaining water; and the epidermis, thus, forms a water-storing tissue. The epidermal cells in the *Cyperaceae*, which form an articulation tissue, have inner-walls angular, so that they come into close contact with the inner cells of the articulation tissue.

The articulation tissue is of epidermal origin and is extensively developed in *Cyperaceae* and *Gramineae*. It usually forms strands of thin-walled cells running between two surfaces of the leaf. In the *Cyperaceae* it forms usually a many-layered tissue in the upper half of the leaf. The margins curve upwards as on a hinge and protect stomata on the upper surface of the leaf in *Gramineae* as well as watery contents in the aqueous cells of the articulation tissue in both the orders.

The epidermis in *Violaceae*, *Celastraceae* and *Gramineae* is characterised by palisade-like elongation of epidermal cells. Large cells, intercalated among ordinary epidermal cells, distinguish *Capparidaceae*, *Elatineae*, *Malvaceae*, *Moringaceae*, *Leguminosae*, *Ficoideae*, *Salvadoraceae* and *Polygonaceae*. Both of these characters are contrivances for storage of water.

The epidermis is sometimes locally two-layered by means of cross walls parallel to the surface, appearing in the epidermal cells of *Violaceae*, *Tamariscineae*, *Burseraceae*, *Celastraceae*, and *Salvadoraceae*. In *Violaceae* and *Burseraceae* the inner walls are gelatinised and a mucilaginous mass is found beneath the division walls. It is usually two-layered in the axis of some of the species of *Polygalaceae*, *Elatineae*, *Geraniaceae*, *Papilionaceae*, *Salvadoraceae*, *Asclepiadaceae* and *Euphorbiaceae*. The occurrence of a two-layered epidermis either locally or throughout intensifies the protective function of the epidermis, namely that of reducing the loss of water by transpiration.

Yellowish contents in the epidermal cells of *Rhamneae* are of the nature of cellulose slime which reduces loss of water by transpiration by thickening the watery contents in the cells. Cystolith-like structures occur in the basal cells of clothing hairs of *Cucurbitaceae* and *Boraginaceae* and also in large cells intercalated amongst ordinary epidermal cells in *Acanthaceae*. Calcareous cystolith-like structures give an acrid taste to juices of foliage and prevent the plants from being easily devoured by animals. The epidermis, in *Actiniopteris dichotoma* which is the only Fern found in the Indian Desert, is mostly sclerosed. This sort of modification of the epidermis is

necessary in plants of the nature of Ferns which wither up at the slightest loss of water.

Stomata.—The stomata usually occur on both the surfaces, except when the aqueous tissue is developed along either of the surfaces. The guard-cells are very thick-walled and vary in their position in different species and sometimes in the same species. They occur (*a*) either only on the lower surface in *Tiliaceae*, *Rhamneae*, *Moringaceae*, some *Ficoideae*, some *Cyperaceae*, some *Gramineae* and *Filicinae*, (*b*) or only on the upper surface in *Onagraceae* and some *Gramineae* (*c*) or equally numerous on both the surfaces in some *Papilionaceae*, *Caesalpineae*, *Mimoseae*, some *Ficoidcae*, some *Compositae*, *Salvadoraceae*, *Gentianaceae*, *Scrophulariaceae* and *Labiatae*, (*d*) or more numerous on the upper surface in *Blepharis* and some *Gramineae*, (*e*) or more numerous on the lower surface as in most of the species.

The stomata are situated above the assimilatory tissue and when the assimilatory tissue occurs nearer the upper or lower surface or only in the upper or lower half of the mesophyll, the stomata accordingly are found on the surface corresponding to that of the assimilatory tissue. In floating plants, such as *Trapa bispinosa* the stomata should naturally occur only on the upper surface.

The greater abundance of stomata on the lower surface is due to the more extensively developed ventilating system in the lower half of the mesophyll; and their equal abundance on both the surfaces is usually due to the bifacial structure of the mesophyll and consequently to the more or less equally developed ventilating system in both the halves of the mesophyll.

The guard-cells may be surrounded by ordinary epidermal cells as in most of the species or are accompanied by subsidiary cells as in *Menispermaceae*, *Cruciferae*, *Violaceae*, *Caryophyllaceae*, *Portulaceae*, *Rubiaceae*, *Salvadoraceae*, *Acanthaceae*, *Verbenaceae*, *Labiatae*, *Commelinaceae*, *Cyperaceae* and *Gramineae*. They are situated either

(*a*) in the same plane as that of surrounding cells, so that the front cavity is placed in a depression formed by outer thickened epidermal walls in *Menispermaceae*, *Cruciferae*, *Capparidaceae*, *Polygalaceae*, *Malvaceae*, *Rhamneae*, *Leguminosae*, *Onagraceae*, some *Ficoidcae*, some *Compositae*, *Salvadoraceae*, some *Asclepiadaceae*, *Boraginaceae*, *Solanaceae*, *Acanthaceae*, some *Amarantaceae*, *Chenopodiaceae*, *Aristolochiaceae*, *Euphorbiaceae*, and some *Gramineae*.

(*b*) or a little below the plane of surrounding cells in *Caryophyllaceae*, *Tamariscineae*, *Zygophyllaceae*, *Simarubaceae*, *Celastraceae* and some *Compositae*.

(*c*) or quite below the surrounding epidermal cells, so that the front cavity is situated at the bottom of a deep pit in *Boraginaceæ* and *Asclepiadaceae.*

(*d*) or a little above the plane of the surrounding cells, so that the front cavity is on a level with the surface in the rest of the orders.

The occurrence of the front cavity in deep pits is necessary in plants which do not possess a hairy covering, so that they can retain a moist atmosphere in the pits, thus reducing transpiration. In *Actiniopteris dichotoma*, which possesses very few stomata on the lower surface and in which the epidermal cells are sclerosed, except on a small portion of the surface where stomata occur, transpiration is a little too much reduced and it is natural that there should be some contrivance, such as elevated position of the guard-cells, to accelerate transpiration in order to get rid of an excess of water. Front cavities, situated on a level with the surface, are usually sufficiently protected against the strong glare and sunlight reflected from the sand by a thick covering of hairs.

In species of *Polygalaceae*, *Tamariscineae*, *Onagraceae* and *Chenopodiaceae* the front cavity is closed by the outer prominent horns of the guard-cells. It seems that in these species the front cavity is not completely closed by ventral walls of the guard-cells. The horns are therefore well developed and completely close the pore by coming into close contact with each other. The guard-cells on the axis of species of *Caryophyllaceae* seem incapable of closing the front cavity of the stomata ; one or more cells in addition to the subsidiary cells, therefore, clasp the guard-cells and thus assist them in closing the pore.

The stomata in *Cyperaceae* are characterised by the occurrence of sub-stomataed air-cavities of obconical shape which are formed by elongated obliquely placed cells.

Assimilatory Tissues.—The chlorophyll tissue is variously differentiated and shows a process of evolution as will be discussed later on. It consists

(*a*) either of a homogeneous tissue of elongated polygonal cells in *Gentianaceæ* and *Filicinae*,

(*b*) or of a homogeneous tissue of arm-palisade cells in some *Compositae*,

(*c*) or of palisade tissue on the adaxial side and of spongy tissue on the abaxial side in some *Capparidaceae*, *Simarubaceae*, *Sapindaceae*, some *Papilionaceae*, *Lythraceae*, *Onagraceae*,

Cucurbitaceae, some *Ficoideae*, *Rubiaceae*, some *Solanaceae*, *Scrophulariaceae*, *Nyctaginaceae*, *Amarantaceae*, *Aristiolochiaceae* and *Euphorbiaceae*,

(*d*) or of a palisade tissue on both adaxial and abaxial sides in *Cruciferae*, some *Capparidaceae*, *Caryophyllaceae*, *Elatineae*, some *Zygophyllaceae*, some *Papilionaceae*, *Caesalpineae*, some *Ficoideae* some *Compositae*, *Salvadoraceae*, some *Asclepiadaceae*, some *Boraginaceae*, some *Convolvulaceae*, some *Solanaceae*, some *Acanthaceae*, and some *Polygonaceae*,

(*e*) or of a homogeneous short-celled palisade tissue in *Menispermaceae*, some *Capparidaceae*, some *Sterculiaceae*, some *Rhamneae*, *Rosaceae* and some *Rubiaceae*,

(*f*) or of palisade parenchyma round the vascular bundles in *Portulaceae*, some *Ficoideae*, *Cyperaceae* and *Gramineae*,

(*g*) or of palisade tissue on the upper side and of arm-palisade on the lower in most of the species with the exceptions that have been mentioned.

From the various modifications of the assimilatory tissue as described above a process of evolution can be traced. The chlorophyll tissue formed of a homogeneous tissue of polygonal cells in *Gentianaceae* and *Filicinae* mark the primary stage from which the various higher stages can be said to have been developed, the assimilatory tissue formed of a homogeneous palisade tissue forming the final stage of development. The arm-palisade tissue represents an intermediate stage between the spongy tissue and palisade tissue. The modification of the spongy tissue into palisade tissue through an intermediate stage of the arm-palisade tissue reduces the ventilating system and consequently transpiration, towards which purpose all the adaptations of desert plants are directed.

The tendency of the chlorenchyma to develop into the palisade tissue is further confirmed by the fact that in the axis, the assimilatory tissue when present, usually consists of arm-palisade cells or of palisade cells.

The arrangement of the palisade tissue in the form of girders round the veins in *Cyperaceae* and *Gramineae* is quite adequate in the leaf-blade which is characterised by an abundant articulation and mechanical tissue. The assimilatory tissue in species of these orders performs its own function and affords room for the development of an articulation and mechanical tissue.

In the centric leaves of *Zygophyllaceae* and *Chenopodiaceae*, the assimilatory tissue forms more or less a sub-epidermal ring enclosing

an extensive aqueous tissue. In the flat leaf-blades with the assimilatory tissue either bifacial or isolateral, there is sometimes a tissue in the middle of the mesophyll and formed of polygonal cells.

(*a*) either colourless and aqueous in some *Cruciferae*, *Salvadoraceae* and some *Boraginaceae*,

(*b*) or assimilatory in some *Cruciferae*, *Asclepiadaceae*, and *Convolvulaceae*,

(*c*) or glandular in some *Boraginaceae* and *Polygonaceae*.

Some of the palisade cells in *Zygophyllum*, *Geraniaceae* and *Rhamneae* are faintly green in colour and may form water storing cells. In many species there occurs a sheath of almost cubical efferent cells, usually green or sometimes colourless, round the veins. The sheath as it usually contains chlorophyll, may assist the assimilatory tissue in photosynthesis, as well as it may form a protective and efferent tissue.

Veins :—The mid-vein is generally vertically transcurrent above and below by means of sclerenchyma, collenchyma or colourless parenchyma, it is usually prominent below and is either grooved or prominent above. In many species, as will be mentioned below, the veins of the ribs being usually vertically transcurrent above and below by sclerenchyma or collenchyma. The smaller veins are either embedded or are vertically transcurrent above and below or apposed to the epidermis on one side and vertically transcurrent by sclerenchyma or collenchyma on the other. The veins in the majority of cases are enclosed in sheaths of large parenchymatous cells, either containing chlorophyll, or being glandular, or colourless or with crystals.

In flattened leaf-blades.—

(*a*) either all veins are vertically transcurrent above and below (i) by sclerenchyma in *Tiliaceae*, some *Papilionaceae*, some *Boraginaceae*, some *Cyperaceae* and some *Gramineae* (ii) by collenchyma in some *Malvaceae* and some *Papilionaceae* (iii) by aqueous cells in some *Cyperaceae* (iv) and by colourless parenchyma in *Celastraceae*,

(*b*) or only the larger veins are vertically transcurrent above and below by colourless parenchyma and collenchyma respectively in *Elatineae* and some *Convolvulaceae*,

(*c*) or only the veins of the ribs of the leaves which are many-ribbed are vertically transcurrent above and below (i) by collenchyma in *Sapindaceae* and *Gentianaceae* (ii) by colourless parenchyma in *Labiatae* (iii) by aqueous tissue above and by collenchyma below in *Geraniaceae* (iv) and

apposed to the epidermis above and with sclerenchyma below in *Commelinaceae*,

(*d*) or the veins are vertically transcurrent only above by colourless parenchyma in *Sterculiaceae* and by collenchyma in *Rosaceae*,

(*e*) or the veins are apposed to the epidermis above and below with sclerenchyma above and below respectively in some *Tiliaceae* and some *Gramineae*,

(*f*) or the veins are embedded in the flat leaves of other species.

In the centric leaves of *Chenopodiaceae* a ring of chlorenchymatous cells, resembling sheath-cells, occurs immediately outside the peripheral veins. The more centrally placed veins traverse the aqueous tissue.

As regards the function of the sheath, it may merely form a protective envelop to the veins resembling endodermis; but as it usually contains chlorophyll it may assist the photosynthetic tissue as well as it may form an efferent tissue. The veins in *Cyperaceae* are enclosed in a ring of stone-cells outside the sheath; the ring of stone-cells seems to form a protective envelope.

Water-storing tracheids occur at intervals between the veins in some *Capparidaceae*, *Tamaricineae*, some *Tiliaceae*, *Simarubaceae*, *Rhamneae* and *Salvadoraceae*. The occurrence of water-storing tracheids in these orders is brought about by their being found usually in the driest portions of the desert. The occurrence of veins in two planes in *Caryophyllaceae* and *Cyperaceae* affords room for the development of a larger number of veins and at the same time gives rigidity to the whole blade.

Hairy covering.—The hairy covering consists of clothing and glandular hairs. The *clothing hairs* may be :—

(*a*) unicellular, either simple or specialised, (*b*) uniseriate, either simple or specialised, (*c*) peltate, (*d*) stellate, (*e*) tufted, (*f*) of the candelabra type and (*g*) shaggy.

(*a*) Simple unicellular hairs may be papillose, elliptical or dome-shaped with walls smooth, muriculate, verrucose, rugose or calcified. They occur in some *Elatineae*, some *Malvaceae*, *Zygophyllaceae*, *Simarubaceae*, *Sapindaceae*, *Moringaceae*, *Mimoseae*, *Lythraceae*, *Ficoideae*, some *Rubiaceae*, *Salvadoraceae*, *Boraginaceae* some *Scrophulariaceae*, some *Acanthaceae*, some *Verbenaceae*, some *Euphorbiaceae* and some *Gramineae*. Special forms of hairs are either hooked as in some *Polygalaceae* or two-armed as in *Cruciferae*. Simple unicellular stiff or woolly hairs of greater length and with walls smooth or muriculate

are found in *Polygalaceae*, some *Elatineae*, *Tiliaceae*, *Rosaceae* and *Filicinae*.

(*b*) Ordinary simple uniseriate trichomes with walls smooth muriculate or papillose occur in *Burseraceae*, *Rhamneae*, some *Papilionaceae*, *Onagraceae*, *Cucurbitaceae*, some *Rubiaceae*, some *Convolvulaceae*, some *Solanaceae*, some *Scrophulariaceae*, some *Acanthaceae*, some *Verbenaceae*, *Labiatae*, some *Amarantaceae*, *Chenopodiaceae* and some *Euphorbiaceae*.

Special forms of uniseriate trichomes belong to the following types:—

(i) Trichomes with walls smooth or verrucose and with a long terminal cell in some *Compositae*, *Asclepiadaceae* and some *Amarantaceae*.

(ii) Trichomes with terminal cell bent like a hook in *Menispermaceae*, some *Papilionaceae*, *Aristolochiaceae* and *Commelinaceae*,

(iii) Two-armed trichomes with equal or unequal arms and with walls smooth or muriculate in some *Papilionaceae*, some *Compositae*, some *Convolvulaceae* and some *Acanthaceae*.

(iv) Adpressed trichomes in some *Papilionaceae*.

(*c*) and (*d*) Peltate and stellate hairs are found in some *Capparidaceae* and some *Ficoideae* respectively.

(*e*) Tufted hairs occur in some *Malvaceae*, *Sterculiaceae*, some *Tiliaceae* and some *Solanaceae*.

(*f*) and (*g*) Candelabra and shaggy hairs are of rare occurrence and are found in some *Amarantaceae* and some *Capparidaceae* respectively.

All the species except the fleshy ones are characterised by a dense covering of clothing hairs of various shapes and structure as described above. It should further be noted that clothing hairs are generally more numerous on the lower surface of the leaves and that they are numerous over and about the veins, some times occurring in groups over and about the mid-rib, though less abundant on other portions of the leaf surface. All these facts may be understood as proofs of localised extra nourishment, especially as they occur in greater abundance about the veins. This is further proved by the fact that fleshy plants belonging to *Zygophyllum* and *Euphorbiaceae* are either glabrous or with a scantily developed covering of clothing hairs.

So it can be said that intense heat and light arrest the development of the parenchymatous tissue, and that the arrest of the development of the parenchymatous tissue is followed by a proportionate development of clothing hairs. It can thus be observed that as transpiration increases, the development of parenchyma is arrested and clothing hairs are produced until the hairy covering is so dense, that it lessens transpiration towards which purpose all the adaptations of the desert plants are directed.

A dense covering of clothing hairs is of invaluable use to desert plants as it forms a non-conducting screen against heat and against the strong glare and sun-light reflected from the sand; it also serves as a means of collecting moisture from the atmosphere at night. For instance a covering of woolly hairs in *Rosaceae*, or of flagellum-hairs in some *Compositae*, or of candelabra hairs in some *Amarantaceae* forms an adequate means of collecting dew at night, which can trickle down the surface of the hairs and be absorbed by the basal cells. In cases of unicellular hair with a thin-walled bulbous basal portion in *Menispermaceae*, *Boraginaceae* and *Gramineae*, dew at night can be easily absorbed by the bulbous basal portion. Clothing hairs, therefore, in many cases perform a double function that of forming a non-conducting screen against intense heat and light and that of absorbing moisture from the atmosphere.

Roughness of the walls caused either by muriculations, or warts, or papillae, as described above, forms a further evidence of the arrest of parenchyma; and that it brings about the interlacing of clothing hairs, so as to produce a thick non-conducting screen of hairs. Clothing hairs, such as woolly, candelabra, flagellum or armed, are usually filled with air, so as to produce a silvery screen which is the best means for reflecting back the strong glare and sun-light in the desert.

For systematic investigations, much importance cannot be given to the characters of clothing hairs, as many types of hairs are found in more than one order, genus and species. It is found, for instance, that tufted hairs are characteristic of three allied orders, viz., *Malvaceae*, *Sterculiaceae* and *Tiliaceae*; so also unicellular and uniseriate hairs occur in four allied orders, viz., *Scrophulariaceae*, *Acanthaceae*, *Verbenaceae* and *Labiatae*. As regards their value in the diagnosis of genera, here again there are forms of hairs which are characteristic of more than one genus; for instance uniseriate trichomes occur in *Crotalaria*, *Rhynchosia*, *Phaseolus* and *Tephrosia*. For diagnosis of species characters of hairs are of still less importance.

Hairiness varies with changes in the surroundings. Not only the density but also the shape and structure of the hair altogether

changes in plants when they are raised in a place with a different condition of soil and climate. Characters of hairs, therefore, will be not only of very little value but will be misleading in the diagnosis of orders, genera and species belonging to places differing greatly in the condition of the soil and climate.

In spite of all this, characters of hairs should not be altogether neglected in the diagnosis of orders, genera, and species belonging to the same place. For instance, shaggy hairs are found in *Cleome*, peltate hairs in *Cadaba* candelabra hairs in *Aerua*, uniseriate trichomes jointed and with the terminal cell bent in *Pupalia*, uniseriate trichomes with a long terminal cell in *Achyranthes*, adpressed uniseriate hairs in *Psoralea*, hooked uniseriate trichomes in *Alysicarpus* and two-armed hairs in *Indigofera*.

It is thus frequently found that certain types of hairs are characteristic of the genera belonging to the same place, though not of the species and orders.

Glandular hairs are of not so common occurrence and are not found in such abundance as clothing hairs. They are rarely found on fleshy plants. The different types of external glands that occur on desert plants are as follows :—

(*a*) Club-shaped.—

(1) With a stalk-cell and with a unicellular head, *e.g.*, *Boraginaceae* and *Labiatae*.

(2) With a stalk-cell and with a head divided by horizontal walls *e.g.*, some *Tiliaceae*, some *Convolvulaceae* and some *Gramineae*.

(3) With a stalk and a head divided by vertical walls, *e.g.*, *Verbenaceae*.

(4) With a stalk-cell and a head divided both by horizontal and vertical walls *e.g.*, *Sterculiaceae*, some *Tiliaceae*, *Papilionaceae*, some *Convolvulaceae* and *Acanthaceae*.

(*b*) Pitcher-shaped.—

(1) With a stalk-cell and with a head divided by horizontal walls, *e.g.*, *Malvaceae*.

(*c*) (1) With a stalk cell and with a head irregularly divided, *e.g.*, *Malvaceae*.

(2) With a stalk cell and with a uniseriate or biseriate head *e.g.*, some *Compositae*.

(*d*) Capitate.—

(1) With a uniseriate stalk and with a unicellular head, *e.g.*, *Geraniaceae*, some *Compositae*, *Labiatae* and *Nyctaginaceae*.

(2) With a uniseriate stalk and with a head divided by a single vertical wall, *e.g.*, *Verbenaceae*.

(3) With a uniseriate stalk and with a head divided by horizontal and vertical walls, *e.g.*, *Cucurbitaceae* and *Acanthaceae*.

(4) With a uniseriate stalk and with a head irregularly divided, *e.g.*, some *Compositae* and *Solanaceae*.

(5) With a biseriate stalk and with a head divided by vertical walls, *e.g.*, some *Compositae*.

(*e*) Shaggy hairs.—

(1) With a multicellular stalk and with a multicellular head, *e.g.*, *Capparidaceae* and *Elatineae*.

(2) With multicellular stalk with a biseriate head, *e.g.*, some *Compositae*.

(*f*) Depressed spherical salt-glands.—

Placed in pits and divided by a single vertical and horizontal wall with two epidermal subsidiary cells at the base, *e.g.*, *Tamariscineae*.

It is very difficult to employ glandular hairs for systematic purposes. Glandular hairs in the first place do not belong to any constant form in a species. The head, especially, varies in structure a great deal; it may be unicellular, uniseriate or biseriate on the same leaf. Besides, the nature of secretion cannot be determined with certainty, especially in herbarium specimens.

External glands are, of course, valuable to the desert plants. They pour their secretions on the surface of the leaf and assist the clothing hairs in protecting the plant structures against intense heat and light, reflected from the sand. In the case of salt-secreting glands in *Tameriscineae*, the pits in which they are situated are filled with secretions of hygroscopic salts which absorb moisture from the atmosphere and supply it to the plants in dry season.

Water Storage Tissues.—Contrivances for water-storage are characteristic of desert plants. Water-storing cells occur in the epidermis, in the middle of the mesophyll in the palisade tissue, in cortex, in pith and in the form of water-storing tracheids.

Large water storing cells bulging inwards and outwards, are intercalated amongst ordinary epidermal cells in some of the species of *Capparidaceae*, *Elatineae*, *Malvaceae*, *Zygophyllaceae*, *Moringaceae*, *Papilionaceae*, *Ficoideae*, *Boraginaceae*, and *Polygonaceae*. Water-storing epidermal cells have the inner walls very thin and convexly arched inwards, so that they come into close contact with the assimilatory tissue, water being thus quickly supplied to it.

The articulation tissue, which is composed of aqueous cells of epidermal origin, is abundantly developed in *Cyperaceae*, *Gramineae*. It regulates the inrolling of the margins, to such an extent sometimes in *Gramineae* that the leaf blades are almost cylindrical, thus protecting the stomata on the upper surface. It may, besides, supply water to the tissues of plants in dry seasons.

A tissue composed of thin-walled colourless parenchymatous cells, is clearly differentiated in the middle of the mesophyll or below the epidermis and may form an aqueous tissue. A clearly differentiated aqueous tissue in the middle of the mesophyll is found in some of the species of *Cruciferae*, *Capparidaceae*, *Portulaceae*, *Salvadoraceae*, *Asclepiadaceae*, and *Boraginaceae*. A sub-epidermal aqueous tissue occurs in some species of *Ficoideae*, *Salvadoraceae*, *Acanthaceae* and *Nyctaginaceae*. In the centric leaves of *Zygophyllum* and of species of *Chenopodiaceae* an extensive aqueous tissue is found in the central portion of the mesophyll.

Groups of palisade cells, faintly green in colour, are found in some of the species of *Rhamneae* and *Cucurbitaceae*, and may serve occasionally as groups of water-storing cells. Lysigenously formed cavities occur frequently in the mesophyll of some of the species of *Polygalaceae*, *Rubiaceae* and *Cyperaceae* and may serve as reservoirs of water.

Water-storing tracheids found either at the terminations of the veins or independently developed at intervals between the veins are the means of supplementing the water supply in some of the species of *Capparidaceae*, *Tiliaceae*, *Simarubaceae*, *Rhamneae* and *Salvadoraceae*. The occurrence of water-storing tracheids in these species, which possess otherwise no aqueous tissue, is necessary on account of the fact that they are usually found on the driest portions of the desert.

Gelatinisation of the inner walls of epidermal cells in species of *Violaceae*, *Burseraceae* and *Sapindaceae* is a means of absorbing and retaining moisture. Mucilaginous tissues also occur in the leaf and axis of some of the species of *Malvaceae*, *Sterculiaceae*, *Tiliaceae*, *Papilionaceae* and *Rosaceae*; and they have the same function.

An aqueous tissue is developed in the cortical parenchyma of the axis of some of the species of *Rosaceae*, *Salvadoraceae*, *Asclepiadaceae*, *Boraginaceae*, *Acanthaceae* and *Chenopodiaceae*. The pith also may sometimes form an aqueous tissue.

The development of an aqueous tissue in the desert plants is the direct result of the arrest of transpiration, which is brought about by thickened and cuticularised or silicified outer epidermal walls,

by a dense covering of hairs and by secretions from the internal glands which thicken the watery contents in the plant tissue, so as to be less easily transpired.

Secretions.—The most common form of secretions is tannin which shows itself by its yellowish colour and which occurs both in the leaf and axis, or only in the leaf or axis. Another secretion of usual occurrence is oxalate of lime in various forms of crystals and occurring abundantly both in the leaf and axis. Silica is abundantly deposited in outer epidermal walls of species of *Cyperaceae* and *Gramineae*. Deposits of carbonate of lime are found in the walls of clothing hairs of some species of *Boraginaceae* and in cystolith-like structures in the basal epidermal cells of clothing hairs of some species of *Cucurbitaceae*, *Boraginaceae* and in the enlarged epidermal cells of the leaf of some species of *Acanthaceae*. Mucilaginous secretory organs occur in a few orders as will be mentioned below. The epidermal cells of the leaves of *Zizyphus* contain cellulose slime. Balsam canals occur in the phloem of vascular bundles in *Burseraceae*. Contents of some of the other secretory organs in the leaf and axis cannot be determined with certainty as I had to deal with herbarium material.

The different types of secretory organs that occur in the desert plants are as follows :—

(*a*) Oxalate of lime.—

(1) Clustered crystals *e.g.*, *Violaceae*, *Polygalaceae*, *Portulaceae*, *Elatineae*, *Malvaceae*, *Tiliaceae*, *Zygophyllaceae*, *Rhamneae*, *Sapindaceae*, *Moringaceae*, *Rosaceae*, *Lythraceae*, *Onagraceae*. *Ficoideae*, *Asclepiadaceae*, *Boraginaceae*, *Convolvulaceae*, *Amarantaceae*, *Chenopodiaceae* and *Polygonaceae*.

(2) Solitary crystals, *e.g.*, *Sterculiaceae*, *Tiliaceae*, *Simarubaceae*, *Burseraceae*, *Boraginaceae*, *Convolvulaceae* and *Euphorbiaceae*.

(3) Acicular raphides *e.g.*, *Ficoideae*, *Rubiaceae*, *Compositae*, *Nyctaginaceae* and *Commelinaceae*.

(4) Styloids *e.g.*, *Ficoideae*.

(5) Clusters of acicular crystals, *e.g.*, *Menispermaceae* and *Gentianaceae*.

(6) Crystal sand, *e.g.*, *Rubiaceae*, *Solanaceae*, *Acanthaceae* and *Nyctaginaceae*.

(*b*) Calcium carbonate deposits, *e.g.*, walls of hairs of *Cruciferae* and *Boraginaceae*.

(*c*) Silica, *e.g.*, *Cyperaceae* and *Gramineae.*

(*d*) Myrosin cells, *e.g.*, *Moringaceae.*

(*e*) Balsam canals, *e.g.*, *Burseraceae.*

(*f*) Cellulose slime, *e.g.*, *Rhamneae.*

(*g*) Cystolith—like structures with calcium carbonate deposits, *e.g.*, *Cucurbitaceae, Borginaceae* and *Acanthaceae.*

(*h*) Secretory cells with mucilaginous membranes *e.g.*, *Tiliaceae, Papilionaceae, Rosaceae* and *Convolvulaceae.*

(*i*) Secretory cavities with a lining epithelium, *e.g.*, *Malvaceae, Sterculiaceae, Tiliaceae, Rhamneae,* and *Rubiaceae.*

(*j*) Tannin.

(1) In the epidermal cells, *e.g.*, *Sterculiaceae* and *Rosaceae.*

(2) In the mesophyll or in the different tissues of the axis, *e.g.*, *Capparidaceae, Caryophyllaceae, Portulaceae, Malvaceae, Sterculiaceae, Celastraceae, Rhamneae, Sapindaceae, Papilionaceae, Mimoseae, Cucurbitaceae, Rubiaceae, Compositae, Asclepiadaceae, Boraginaceae, Convolvulaceae, Nyctaginaceae, Polygonaceae, Euphorbiaceae, Commelinaceae,* and *Cyperaceae.*

Crystals of different forms may occur in the same plant either in the same tissue or in different tissues. They usually occur in the lumina of the cells except in species of *Nyctaginaceae* in which crystal sand is deposited in the outer walls of epidermal cells. The employment of different types of crystals for systematic purposes is not desirable, as solitary or clustered crystals may occur at different stages of development of the plant tissues.

Crystals of oxalate of lime occur usually near the veins and it appears that secretions of oxalate of lime gives acridity to the tissues of the plants and prevents the plants from being easily devoured by animals.

Tannin is abundantly found in different tissues of the plant usually near the veins; and it seems to protect the plants in various ways. It gives acridity to the juices of the plant and prevents it from being easily devoured by animals. Tannin sacs, as they usually occur near the vascular bundles of the veins, pour their secretions into the water, which is consequently less easily transpired. Besides its general property of protecting the plant-tissues against desiccation, it may be used up in lignification of cells, as lignification is a prominent feature in the desert plants.

Cells with mucilaginous membranes and secretory cavities which may also be mucilaginous in *Malvaceae, Sterculiaceae* and

Tiliaceae have the property of absorbing and retaining water, and may serve indirectly as a water-storing tissue. Secretions of mucilage thicken the water in the leaf and render it less easily transpired.

Deposits of calcium carbonate in the walls of clothing hairs of *Cruciferae* and *Boraginaceae* may absorb moisture by their hygroscopic property and add to the water supply of the plant. The abundance of silica in the outer walls of the epidermal cells in *Cyperaceae* and *Gramineae* affords effective protection against the attacks of animals and adds to the rigidity of the plant which is necessary against the strong winds of the desert.

Sclerotic Modifications of the Pericycle.—The pericycle is composed either of a composite and continuous ring of stone-cells or of bast fibres, or of large closely placed groups of stone-cells or bast fibres, or of a loose ring of stone cells or bast fibres. In a few cases it consists of a few isolated stone-cells or bast fibres.

A sclerenchymatous pericycle is not developed in a few orders as will be mentioned below. The abundant development of sclerenchyma in the pericycle is due to the arrest of parenchyma, owing to the deficiency of water. This can be seen from the fact that parenchyma is abundantly developed and that a sclerenchymatous pericycle is altogether absent in fleshy plants of *Violaceae*, *Portulaceae*, *Burseraceae*, *Rosaceae* and *Gentianaceae*. A sclerenchymatous pericycle serves as a supporting tissue against the strong winds of the desert.

In some species of *Compositae*, *Verbenaceae*, *Amarantaceae* and *Chenopodiaceae* the pericycle presents an isobilateral symmetry which is caused by unequal development of pericyclic sclerenchyma in the two planes, larger groups of stone cells or of bast fibres being developed in the plane which corresponds with the direction of the prevailing wind. In inclined axes of some species of *Zygophyllaceae*, *Papilionaceae* and *Convolvulaceae* the tissue of stone-cells or of bast fibres is abundantly developed on one side which seems to be the upper side of the axis, while on the other side the pericycle consists of a few isolated small groups of stone cells or of bast fibres. The abundant development of a supporting tissue on the upper side is necessary to protect the axis from the stretching strains on the upper side and consequently from bending.

The different types of the pericycle that occur in the axis of the desert plants are as follows :—

(*a*) Isolated stone-cells or small groups of stone-cells, *e.g.* *Elatineae*, *Boraginaceae*, and *Convolvulaceae*.

(*b*) A loose ring of small groups of stone-cells *e.g. Elatineae.*

(*c*) Large closely placed groups of stone-cells *e.g. Menispermaceae, Capparidaceae, Caryophyllaceae, Tamariscineae, Malvaceae, Sterculiaceae, Tiliaceae, Zygophyllaceae, Simarubaceae, Celastraceae, Cucurbitaceae, Ficoideae, Compositae, Salvadoraceae, Asclepiadaceae, Boraginaceae, Convolvulaceae, Verbenaceae, Labiatae, Amarantaceae, Chenopodiaceae,* and *Polygonaceae.*

(*d*) A composite and continuous ring of stone-cells, *e.g. Sapindaceae, Papilionaceae, Caesalpineae, Mimoseae, Cucurbitaceae, Ficoideae, Compositae, Convolvulaceae, Verbenaceae, Liliaceae,* and *Commelinaceae.*

(*e*) Isolated bast fibres or small groups of bast fibres, *e.g. Cruciferae, Scrophulariaceae, Acanthaceae, Nyctaginaceae* and *Euphorbiaceae.*

(*f*) A loose ring of small groups of bast fibres, *e.g. Lythraceae, Rubiaceae, Solanaceae, Scrophulariaceae, Nyctaginaceae* and *Euphorbiaceae.*

(*g*) Large closely placed groups of bast fibres, *e.g. Cruciferae, Sterculiaceae* and *Asclepiadaceae.*

(*h*) A composite and continuous ring of bast fibres, *e.g., Polygalaceae, Rhamneae* and *Papilionaceae.*

In addition to the sclerenchymatous pericycle small groups of stone cells and of bast fibres occur in the soft bast of some species of *Rhamneae* and *Malvaceae*, respectively.

In *Melhania Denhami* the pericycle is represented by an outer composite and continuous ring of stone cells and of an inner ring of groups of bast fibres with parenchymatous pericycle intercalated between them. The composite and continuous ring of bast fibres in *Polygala erioptera* is stratified.

For employing characters of the pericycle for systematic purposes, it is necessary to follow the progressive development as well as the modifications which it undergoes. For differentiation of the pericycle may vary in branches of different thickness.

Conducting system.—The wood usually forms a composite hollow cylinder. Vessels are less abundantly developed in desert plants than in ordinary mesophytes. This is quite natural, when all the tissues in desert plants are adapted to check transpiration, owing to the deficiency of water. The vessels are embedded in a ground tissue of wood prosenchyma which is usually formed of cells with thickened and lignified walls and with small lumina. The occurrence of ligni-

fied ground tissue in the wood and the narrowness of medullary rays, when present, are characteristic of desert plants.

Interfascicular wood prosenchyma is scantily developed in the herbaceous species of *Violaceae*, *Malvaceae*, *Zygophyllaceae*, *Celastraceae*, *Ficoideae*, *Rubiaceae*, *Compositae*, *Salvadoraceae*, *Gentianaceae*, *Boraginaceae*, *Convolvulaceae*, *Scrophulariaceae* and *Acanthaceae*. It is altogether absent in *Menispermaceae*, some *Capparidaceae*, *Caryophyllaceae* and *Rosaceae*. It may be observed that interfascicular wood prosenchyma is abundantly developed and is composed of cells with thickened and lignified walls and with small lumina in shrubs and undershrubs; and that in herbaceous species it is either altogether absent, or is scantily developed and is formed of cells with walls less thickened and with lumina much larger. The abundance of vessels is inversely proportional to that of interfascicular wood prosenchyma. The medullary rays are very narrow and are formed of thick-walled cells in shrubs and undershrubs. They are broader in herbaceous species of *Menispermaceae*, *Tamariscineae*, *Rosaceae* and *Salvadoraceae*. They are altogether absent in *Cruciferae*, *Caryophyllaceae*, *Sapindaceae*, some *Compositae*, some *Amarantaceae* and some *Chenopodiaceae*.

In succulent species of *Chenopodiaceae* the vascular system is composed of peripheral bundles traversing the aqueous tissue and of a central vascular cylinder. The former strengthens the aqueous tissue and brings about quick translocation of water in the aqueous tissue.

In *Monocotyledons* the peripheral vascular bundles are either apposed or embedded in the stereome tube or girders. Vascular bundles in *Cyperaceae* are enclosed in a ring of stone cells.

There are a number of anamolous structures which are perhaps brought about by the effects of environment and which are as follows:

(*a*) Cortical vascular Bundles *e.g. Crotalaria Burhia.*

(*b*) Medullary vascular bundles e.g. some species of *Malvaceae* and of *Amarantaceae.*

(*c*) A ring of larger vascular bundles in the medullary tissue *e.g. Nyctaginaceae.*

(*d*) Isolated vessels in the medullary tissue *e.g. Commelinaceae.*

(*e*) Xylem bundles in the soft bast *e.g. Simarubaceae* and *Burseraceae.*

The development of a ring of large xylem bundles with large vessels in the pith of rhizomatous axes of *Aerua tomentosa* may be an adaptation to protect the axis against longitudinal pressure in the soil.

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ABBREVIATIONS

W.—Water-storing tracheid.
L. C.—Lysigenous cavity.
A.—Water-storing cell.
B. C.—Balsam canal.
G.—Internal secretory cell.
A. R.—Acicular raphides.
Cl.—Collenchyma.
Z.—Anomalous xylem bundles.
C.—Cork.
S.—Stone tissue.
C. P.—Cortical parenchyma.
P.—Soft bast.
G. A.—Assimilatory tissue.
Ep.—Epidermis.
S. R.—Secretory receptacle.
S. C.—Secretory receptacle.
S. cl.—Small-celled collenchyma.
S. V.—Sieve-sclereid.
C. S. Crystal Sand.
X.—Xylem.
G. T.—Ground tissue.
S.—Small stone cells.
T. S.—Transverse section.
Oc.—Ocular.
Oc. Com.—Compens. ocular.
Ob.—Objective.
Ap.—Apochromat.

TWO NEW SPECIES OF POLYPORACEAE.

BY

S. R. Bose, M.A., F.L.S.

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I am making a systematic study of Polyporaceæ of Bengal and Agaricaceae of my neighbouring places. I am bringing them out in series in our College Bulletins and some of the local journals. But little work has been done on Bengal Fungi (specially Polyporaceae and Agaricaceae). Berkeley published notes on some collected by Sir J. D. Hooker in Darjeeling and Himalayan hilly tracts in Hooker's Journal of Botany, Vols. II, III, IV and VI; but since then there has been hardly any accountable work beyond identification of stray collections by Currey, Massee and Lloyd. Most of my specimens which have already been published, I had worked out at the Mycological Herbarium of Peradeniya Royal Botanical Gardens, Ceylon, with the kind assistance of Mr. T. Petch, the indefatigable worker on Ceylon Fungi. Some were sent to Mr. Lloyd the famous Mycologist of Cincinnati, Ohio, who has undoubtedly the largest collection of Polyporaceae from all different parts of the world. After very careful scrutiny, Mr. Lloyd has confirmed the following two as new species. I am sincerely grateful to him for the trouble he has taken in matching them with the rich collection of Polypores.

1. Polyporus friabilis., sp. nov.

Habitat—Growing from the ground, collected from Nagbol (Hooghly Dist.), in June, 1919 and from the interior of Howrah Dist. on 13th October, 1919 and on rocky soil from Udaigiri, Puri (Orissa) in November 1920, and from Coimbatore, Madras, in March, 1921.

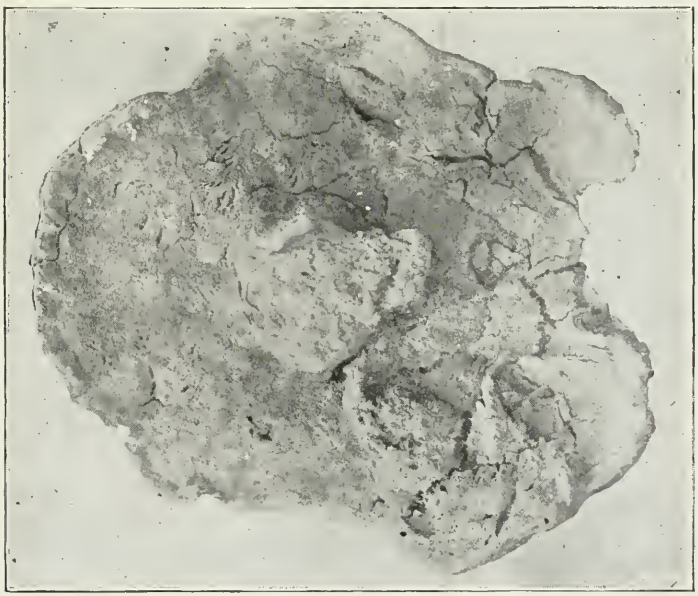
Pileus—Stalked, mostly mesopodial, in one case lateral, soft, becomes a bit hard in drying up, mostly circular in form, about 6 cm. across, the bigger one from Howrah has a diameter of about 17 cm. and is about 12 mm. thick. others about 3 mm. thick. It is a fleshy species, and has an offensive smell all over when fresh.

Stalk—Concolorous with the pileus, short, 1½ to 3 cm. long, 1½ to 3 cm. thick (the bigger one 3 cm. thick).

Upper surface—Smooth, soft, not zoned, but wrinkled, colour yellowish-grey when fresh, acquires a brownish tinge here and there in drying.



Bose] No. 1. POLYPORUS FRIABILIS, Sp. Nov.
(Upper surface). About half the original size.



Bose] No. 1. POLYPORUS FRIABILIS, Sp. Nov.
(Lower surface). About half the original size.



Bose] No. 2. POLYSTICTUS SARBADHIKARII, Sp. Nov.
(Upper surface)



Bose] No. 2. POLYSTICTUS SARBADHIKARII, Sp. Nov.
(Lower surface)

Hymenial surface—Of the same color, becomes brownish in drying, pores small and angular, pore tubes in the bigger specimen 8 mm. long, context yellowish, soft, brittle and friable.

Margin—In dried ones involute.

Cystidia—None.

Spores—Hyaline, smooth, oval $4 \times 6\mu$; some round, 6μ in diameter.

Mr. Lloyd remarks: "It belongs in section 39 of Stip. Polyp. pamphlet and is suggestive of Polyporus ovinus of Europe. The soft, friable flesh of the dried specimen is a feature not known to me in any similar species"

It has been named friabilis on account of its soft friable context. For this suggestion of name I am indebted to Mr. Lloyd.

2. Polystictus Sarbadhikarii, sp. nov.

Habitat—Growing in clusters in imbricate manner on dead trunk of Tamarind tree, collected from Nagbol, Hooghli Dist., in July, 1919.

Pileus—Sessile, arising as lateral outgrowths in imbricate manner from the dead stump, in the form of an arc of a circle, hard, about 3 cm. long, about 2 cm. broad, about 8 mm. thick, internally yellowish-brown.

Upper surface—Brown, distinctly hairy, brown hairs a bit coarse, and arranged in regular concentric zones on the upper surface.

Hymenial surface—Dark-brown, pores uniform, minute, brown, pore-tubes short, 2 mm. long, context a bit hard.

Margin—With a black outline.

Spores—Deep brown, round, diameter 9.09μ.

Setæ—None.

Mr. Lloyd says: "I cannot place a name for it. It is in section close to Polystictus subcogener."

LANTANA IN CEYLON.

BY

T. PETCH

Peradeniya, Ceylon.

In Memoirs of the Department of Agriculture in India, Vol. V, No. 6, Rao Sahib Y. Ramachandra Rao has presented a paper on *Lantana* insects in India which is of interest to botanists, as it includes a comprehensive account of the host plants, one at least of which, *Lantana aculeata*, is a troublesome weed in many parts of the Eastern Tropics.

As regards the status of *Lantana*, Ceylon constitutes an exception to the general experience. In Ceylon, *Lantana aculeata* is common enough, but it is not looked upon as a troublesome weed. Indeed, the tendency is rather to regard it as beneficial, since it rapidly takes possession of waste ground and thereby prevents denudation or deterioration of the soil by exposure.

Ceylon, however, comes in for special consideration by investigators of the *Lantana* problem, as the possessor of a plant, *Tithonia diversifolia*, which is alleged to kill out *Lantana*. This idea appears to have originated about 1890, and it was given currency outside Ceylon by Mr. John Ross, a resident in Hawaii, who published a note on the subject in the Planters' Monthly (Honolulu), vol. X, pp. 436, 437 (October, 1891).

Mr. Ross had met Lieutenant-General Sir Allen Johnson " of the British Army in India " and, on explaining to the latter how " *Lantana* was fast getting a ruinous control of the best pasture lands," was informed by him that in Ceylon " they were having a similar experience to us, but that lately they were getting it under control through the agency of a particular kind of sun-flower imported there." In consequence, Mr. Ross communicated with Ceylon, and obtained seeds of the sunflower in question, accompanied by a letter from Trimen, from which the following extract was published (loc. cit.).

" The plant referred to by Mr. Ross is, no doubt, the Californian sun-flower, *Tithonia diversifolia*, the brilliantly yellow-flowered weed so conspicuous on waste ground in Ceylon.

" I have recently pointed out to several visitors here the curious fact that, when growing along with *Lantana*, this gradually kills out

the latter; the modus operandi obviously being that it grows taller, and, by its large leaves, keeps out the sunlight, without which the *Lantana* cannot exist. No doubt some report of this has been carried to Hawaii. I do not think, however, that *Tithonia* has ever yet been sown in Ceylon with the object of destroying *Lantana*; indeed, one weed is little better than the other.

"There is no difficulty in obtaining seed in any quantity.

HENRY TRIMEN,
Director, Royal Botanical Gardens.

COLOMBO,
August 15th, 1891.

Trimen does not appear to have made any direct publication on the subject.

Ceylon botanists at the present time would hesitate to affirm that *Tithonia* kills out *Lantana* to any marked extent, though where the two grow together the process described by Trimen may operate. This is assisted on waste land by the side of the railway by the periodic cutting back of the vegetation, as *Tithonia* develops a large stool from which new shoots spring up rapidly after cutting and smother slower-growing species. But *Tithonia* appears to prefer damper localities than *Lantana*. It is especially luxuriant along the banks of rivers, and here in many cases it occupies the lower parts of the sloping banks while *Lantana* flourishes in the drier upper parts. As regards their relative status as weeds,—it is more difficult to get rid of *Tithonia* than *Lantana*, because of the more extensive development of the rootstock of the former.

Tithonia diversifolia was not introduced into Ceylon with the object of killing out *Lantana*. It was introduced as a garden plant in 1851, and soon escaped from cultivation. Seeds were, however, sent to Hawaii for that purpose.

The author of the Memoir states that *Lantana* is reported to have been introduced into Ceylon about 1824 and that it is probable that it reached India about the same time. It is very difficult to fix the dates of introduction into Ceylon of the earlier exotics, as few of the early records are extant. This is no doubt due in part to the frequent changes of Superintendents during the twenty-five years following the removal of the Botanic Garden to Peradeniya, as these changes must have made it impossible to establish any proper organisation. Moreover, owing to lack of adequate office room and furniture, records were stored in cases on the verandah of the Superintendent's bungalow, where they were inevitably destroyed by white ants. There is also the further extenuating fact that on the death of each

successive Superintendent,—and six died between 1825 and 1849—all papers were removed to the Kachcheri in the neighbouring town of Kandy; and three removals being as bad as a fire, they probably suffered some loss in consequence.

The approximate dates of introduction of the earlier species were worked out by Trimen, and included by him in his Hortus Zeylanicus (1888). These were deduced chiefly from the records and specimens of botanists who visited Ceylon before the establishment of a Botanic Garden. For example, if Trimen stated that a given species was introduced before 1678, that means that the species was recorded or collected by Hermann. Similarly, the date 1824 signifies that the plant in question was enumerated by Moon in his Catalogue of Ceylon Plants. Moon's records, however, are to be accepted with reserve, as in very few cases are there any specimens in support of them.

The first record of *Lantana* for Ceylon was made by Moon, who recorded *Lantana trifolia*, as an introduced plant, in his Catalogue published in 1824. As it is included in the Additions, not in the main body of the Catalogue, it was probably introduced while the book was in the press. Moon cites Bot. Mag. t. 1449, hence it is assumed that his identification was correct. But Moon's plant, *Lantana trifolia*, is a common weed only at high elevations; it is not the common Lantana of the low country.

Colonel and Mrs. Walker who enumerated the plants met with between Ratnapura and Adam's Peak in the Colombo Journal, 1833, did not mention *Lantana*. Again, Mrs. Walker, in describing a tour in the low-country in Hooker's Journal of Botany, II (1840), pp. 223-256, made no reference to it. Champion (Hooker's Journal of Botany, III (1841), pp. 282-292) recorded that *Lantana aculeata* occurred round Colombo in 1839; and in 1843, he enumerated *Lantana* sp. among the predominating shrubs and plants from sea level to 2,000-3,000 ft. As the native *Lantana indica* is very rare in Ceylon, the latter record is not likely to refer to that. Finally, Gardner, in "Some general remarks on the Flora of Ceylon' (1848), referred to "The Lantanas which are to be met with almost everywhere in bushy places and hedges."

Trimen did not assign a date to the introduction of *Lantana aculeata* in his Hortus Zeylanicus (1888). In the Flora of Ceylon, III, p. 346, he stated that it was introduced soon after 1824 and added that its introduction was attributed to Sir Hudson Low, who held a military command in Ceylon in 1826. As it had become a weed by 1839, the suggested date is probably correct.

As regards the introduction of *Lantana* into India, it is to be noted that Hortus Bengalensis (1814) records *Lantana trifolia*, presented to the Garden by Dr. W. Carey in 1807, and *Lantana aculeata*, presented by W. Hamilton in 1809. Thus both plants were known in India many years prior to their introduction into Ceylon, and, taking into account the fact that in the early days of the Ceylon Botanic Garden the bulk of its accessions were obtained from India, it is most probable that both were introduced into Ceylon from India.

The colour of the flowers of *Lantana aculeata* changes from orange-yellow to red as the flower matures. Some years ago, the question was raised by an entomologist whether the colour change was related to pollination, and, though that did not appear probable, the following tests were carried out.

An inflorescence was enclosed in a glass tube which was plugged with cotton wool. Care was taken to see that no insects were present. The flowers expanded normally, the colour change of the individual florets occurring in two to three days. No achenes ripened. This was repeated with two more inflorescences with the same result. The colour change is, therefore, independent of pollination. Two inflorescences which were left free during the same period ripened three and five achenes respectively.

[NOTE.—With regard to the name to be adopted for the common Lantana, the following notes may be of interest from a historical standpoint, though the final settlement must depend upon an examination of the material on which the Linnæan citations were based, and a determination of the plants in their native country. I am not aware of any recent discussion of the question.

According to Systema Naturae, Ed. XIII (Gmelin 1791), Linnaeus distinguished *Lantana aculeata* and *L. Camara* as follows,—

Lantana aculeata, foliis oppositis, caule aculeato ramoso, spicis hemisphaericis. Mant., p. 419. Plukn., Alm., t. 233, f. 5. Gaertn., de fr. et sem., cent. 4, t. 56, f. 4.

Lantana Camara, foliis oppositis, caule inerme ramoso, floribus capitato-umbellatis aphyllis. Dill., H. Elth., t. 56, f. 65.

Schauer, in DC. Prod., XI (1847), made *Lantana aculeata* L. a form of *Lantana Camara* L., " forma caule magis aculeato ; " and described *L. Camara* as " ramis patentibus tetragonis cum pedunculis pubescentibus vel hirto-pilosis aculeatis subinermibusve scabris." He cited the figure in Dillenius, Hort. Elth., but not that in Plukenet. According to Schauer, *L. camara* may be prickly or not. It would seem that this point can only be decided in America ; certainly the Ceylon form is always prickly.

Thwaites, in Enumeratio Plantarum Zeylaniae (1861), assigned the Ceylon Low-country weed to *Lantana mixta* L. This was apparently an error. *L. mixta* L., *fide* Schauer, is distinct from *L. Camara* L. and *L. aculeata* L.

C. B. Clarke, in Flora British India, IV, p. 562, (1885) followed Schauer referring the common Indian and Ceylon plant to *Lantana Camara* L, and citing its previous identifications as *Lantana aculeata* L. in Roxb. Hort. Beng. 46, and as *L. mixta* L. in Thwaites, Enum. Plant. Zeyl., 242.

Trimen, Handbook of the Flora of Ceylon, III, p. 346 (1895), wrote "With regard to the right name for this common weed, *L. mixta* L. is adopted by Thwaites, and *L. Camara* L. in Flora British India, IV, 562; but our plant is always prickly, and is well represented in the figure quoted by Linnaeus for his L. *aculeata* (Plukenet, Phyt., t. 233, f. 5), made from a plant then (1696) in cultivation at Hampton Court."

Cooke, Flora of the Bombay Presidency, II, p. 419 (1905), follows Flora British India in adopting the name *L. Camara* L. for the prickly species with orange-coloured flowers, and cites *L. aculeata* L. as a synonym.

Ceylon botanists have followed Trimen in regarding *L. aculeata* as distinct from, not a form of, *L. Camara*. In Ceylon we have, as far as has yet been recorded, only the yellow-red-flowered form of this species.

T. PETCH.

THE INDIAN SPECIES OF ERIOCAULON

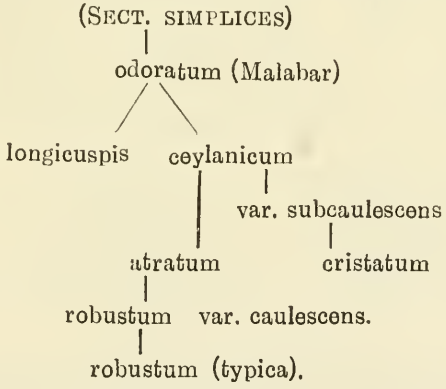
By P. F. Fyson, M.A., F.L.S.,
Presidency College, Madras.

(*Continued from p. 266.*)

IV. ANISOPETALAE.

The male flowers have one petal much enlarged and projecting beyond the floral bracts, covering them : in the larger species this petal has a very conspicious black gland. Otherwise the flowers are normal : the male calyx united as a spathe split in front ; the anthers black ; the female flowers with three more or less boat-shaped sepals and three oblanceolate somewhat hairy petals. The stem is occasionally elongate, and even branched and suffruticescent. The heads are mostly semi-globular, with a convex, sometimes tall, hairy receptacle. The leaves are glabrous, and in most species characteristically thick and glossy. The involucral bracts may be dark or pale, even in the same species.

TABLE OF PROBABLE RELATIONSHIPS.



The series seems to start with *E. odoratum*, or perhaps *E. longicuspis*, and to connect with the SIMPLICES through *E. collinum*. It is chiefly developed in Ceylon, where the several species of other authors, *subcaulescens*, *ceylanicum*, *atratum* and *sub-glaucum*, are distinguishable, if the sheets in the Ceylon Herbarium are rightly so named, by characters of only minor importance, and lead by hardly more than increase in size and general robustness to *E. caulescens* Hook. f. ; which again differs only in being branched from *E. robustum*

of the Nilgiris, an older species, to which therefore I reduce it. There is no difference except in the number of scapes between *E. policephalum* Hook. f. of Central India and *E. longicuspis* Hook. f. of Ceylon.

Key to the Anisopetalae.

* Heads 1/6-1/4 in. diam.

Ls. 1-1½ in., lanceolate; scapes 6-10 in. (Malabar) ... 28 E. odoratum

Ls. 2½-3 in., linear from a broad base; (scapes 12-18 in Khasia) ... 33 E. cristatum.

* * Heads 1/4-1/2 in. diam.

Floral bracts acuminate (Central India and Ceylon) ... 29 E. longicuspis.

Floral bracts not acuminate (Ceylon)—

Involucre black ... 30 E. atratum.

Involucre white ... 31 E. ceylanicium.

* * * Heads 1/2—1 in. diam.

Stem stout, short or caulescent (S. India and Ceylon) ... 32 E. robustum.

28. **E. odoratum** Dalz. F.B.I. vi. 574, No. 9; Ruhl. No. 187. Stem disciform. Leaves 1-3 in, by 1/8 in. at the base, and narrowed to the acuminate apex. Scape filiform, 6-10 in., deeply grooved. Heads 1/6-1/4 in. snow white; bracts cuspidately acuminate. Sepals of the female flowers 3 or 2 only; otherwise flowers normal. Female petals with large glands. Smells strongly of camomile (*Dalz*). Plate 24.

The Concan, "in standing water" (F.B.I.) Malabar, ft. Sept. (*Dalz*).

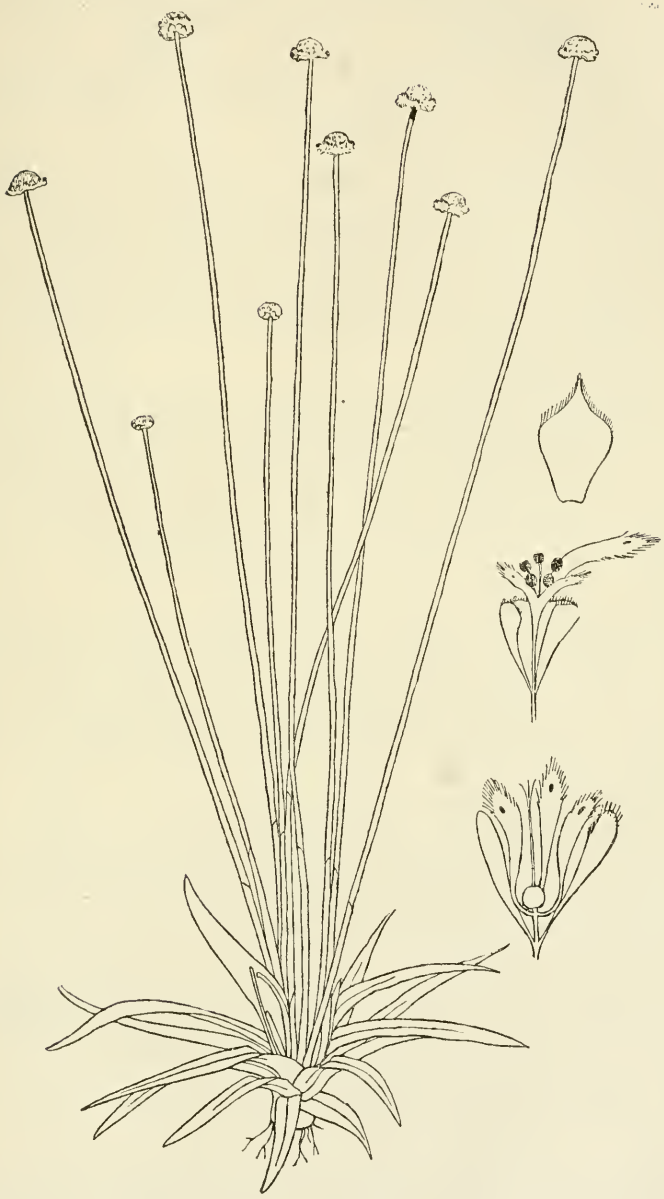
I have seen only two sheets, both in Herb. Calc. One coll. by Hooker and Thomson, has apparently the female sepals 2 only, and black involucral bracts. The other Meebold No. 9889, has the female sepals 3 and the bracts pale. In other respects and especially in the large glands of the female petals they are alike. Hooker in F.B.I. describes the female sepals as longer than the petals.

29. **E. longicuspis** Hook. f. (C.P. 789 in Herb. Ceylon!) F.B.I. vi, 573, No. 7 and 8; Ruhl. p. 116 "incognita."

Stem disciform, leaves usually 3 (2-8) in. Bracts acuminate, fringed with white hairs, and more or less hidden by the projecting male petals the lowest of which form a conspicious fringe round the head. Flowers regular and normal. Plate 25 and fig. opposite.

Var. *a. typica* scape solitary. Ceylon.

Var. *b. polycephalum*. Hook. f. (Duthie 10,580 in Herb. Calc!) F.B.I. l.c. No. 8. Scapes numerous, otherwise as type.



D. R. Fyson ERIOCAULON LONGICUSPIS. *Hook. f., var. polycephala.*

Central India, Pachmarchi; Peninsular India, Mysore, Palghat.

I can see no difference except in the numerous scapes between this and *E. longicuspis*.

A plant collected by Dr. Henry in Yuman, No. 9443 in Herb. Calc. has smaller leaves more like those of *E. odoratum* and smaller heads. The involucral bracts are not reflexed. It may be a distinct species but is obviously closely related to *E. longicuspis*.

30. **E. atratum** Koern., F.B.I. vi, 574, No. 10; Ruhl. see p. 69 Stem up to 3 in. thickly covered with leaves. Leaves 1/4-1/3 in. wide at the base, then suddenly narrowed and bluntly linear, many nerved. Scapes solitary or few, 7-15 in. Heads 1/4-1/3 in. diam. Involucre black. Floral bracts, white, concealed by the long-fringed male petals. Plate 26.

Ceylon, Adam's Peak.

There seems to have been some confusion with regard to this species. In Herb Ceylon is a sheet marked "Galagama February 1816, O.C. 932" and "C.P. 61" and this last number is also borne by another sheet, of the next species. Ruhland says the plant called *atratum* by Hooker in Fl. Ceylon is not Koerniche's species, but he does not say what is, and founds a new species E. *subglaucum* on one of these former, which one I do not know. Koerniche in Linnaea xxvii p. 611 says the involucre is black.

31. **E. ceylanicum** Koern, Fl. Ceylon, v, 3, No. 4; Ruhl. No. 128; (E. subcaulescens, Hook f. F.B.I. vi, 583; Ruhl. No. 116) Similar to *E. atratum* but the heads larger and involucre white or yellowish. Protruding male petals perhaps more conspicious. Plate 27.

Var. *a. typica*. Stem 0, leaves linear, 2-6 ins. by 1/10 ins., from a broader base.

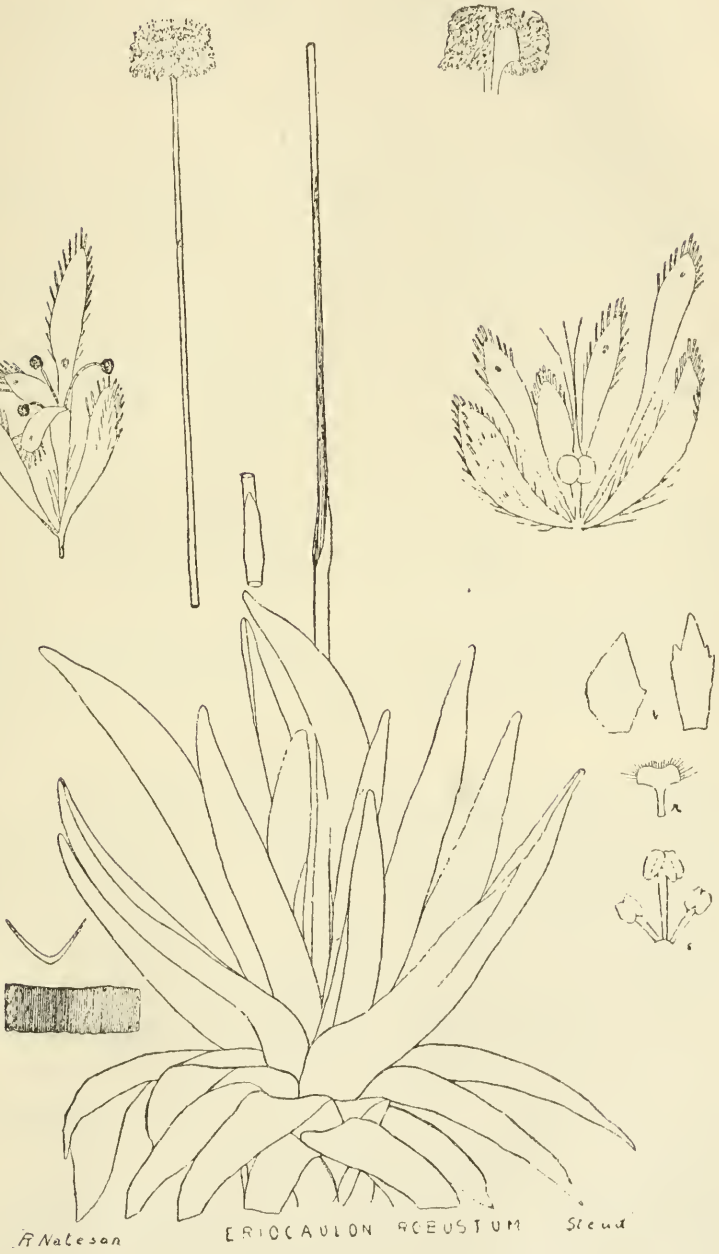
Ceylon, Eliya lake.

Var. *b. subcaulescens*. Hook f. Stem to 2 ins. Leaves narrow 2-4 ins. by 1/6 ins., slightly broader at the base. Scapes stouter, but heads exactly as in the type species of which this appears to be more developed or a form of drier positions. Plate 28.

Ceylon; Horton Plain.

This species is very closely allied to *E. atratum*, and if the involucral bracts of the latter vary, as stated by Hooker in Fl. Ceylon from black to yellowish, all these forms should be included under one species. The only other real distinction given by Hooker is that the lower floral bracts of *E. atratum* are very shortly cuspidate, the upper being acute (as in *E. ceylanicum*). Ruhland makes three species of these forms.

32. **E. robustum** Steudel, F.B.I. vi, 572, No. 5; Ruhl. No. 120. Stem short and stout to as much as 1 in. in thickness: thinner and branched in var. *b*. Ls. up to 12 in. by 2 in., many nerved, glossy, coriaceous. Scapes to 24 in. Heads $1\frac{1}{4}$ in. Involucre white or


R Naleson
ERIOCAULON ACEUSTUM Steud

gray. Floral bracts acute, ciliate, entirely hidden when those are fully out by the very large protruding male petals. Receptacle hour-glass shape. Plate 29.

South India ; Nilgiris 5—6,000 ft.

Var. *b. caulescens.* Hook. f. and Thoms. F.B.I. vi, 572, No. 5 ; Ruhl. as *E. atratum* var. *major* No. 74.

Stem 3-10 in. branched, the lower parts covered with leaf-bases Leaves narrowed above the broad base, and then 1/4 in. wide or less by 3-6 in. Scapes 6-25 in. Involucre black. Plate 30.

Ceylon : Horton Plain. Adam's Peak.

There is no real difference except in the stem and its branching from *E. robustum.* A piece of the Ceylon plant is indistinguishable from a not very robust Nilgiri one. I have therefore no hesitation in uniting this as a variety to *E. robustom*, though Hooker founded a new species for it, and Ruhland followed Thwaites in calling it var *major* of *E. atratum.* The fresh flower heads have the scent of a *Chrysanthemum.*

33. **E. cristatum** Mart., F.B.I. vi, 574 ; Ruhl. No. 118, stem short, or up to 1 in. Leaves linear to 6 in. by 1/6 in., many nerved, not much enlarged at the base. Scapes 6-15 in. Heads 1/3 in. Involucre black or white. Floral bracts deltoid. Receptacle not very hairy. Plate 31.

Assam ; Khasia ; Bengal.

Some of the heads have a fringe of protruding male petals as in *E. longicuspis*, but because of the broad leaf-bases I am inclined to regard this as more nearly related to *E. ceylanicum.*

V. SEARIOSAE

Both involucral and floral bracts scarious without any trace of dark colour, and tending to become hairy and acuminate. Receptacle villous. Flowers perfect or more often very small and reduced by omission of one or more parts. Stem in all disciform and leaves glabrous. Involucre hairy.

Key

Heads 1/3 in., conical ; floral bracts acuminate ; female sepals 3. (Nepal to Pegu) ... 34 E. oryzetorum.

Heads 1/8 in, to 1/6 in., conical ; floral bracts acute ; female sepals 2 (Assam to Tavoy and Western Ghats) ... 35 E. Hamiltonianum;

Heads 1/6 in. globose ; female sepals 2, petals 2 or o ; involucral bracts longer than the head (Sikkim to Chota Nagpur) ... 36 E. Edwardii.

34. **E. oryzetorum** Mart. (Wall. Cat. 6069 in Herb. Calc.!) F.B.I. vi, 579, No. 25 in part ; Ruhl. No. 126. Annual (*Mart.*)

Leaves 2-3 in. by 1/6 in. Sheaths as long. Scapes several, slender 12-17 in. Heads 1/3 in. Involucral bracts blunt; floral acuminate scabrid. Flowers normal. Plate 32.

C. Himalayas; Nepal and southwards to Chota Nagpur and Burma Pegu.

Mart. in Wall Pl. As. Rar. iii·gives floral bracts as " dorso-barbulatis ".

35. **E. Hamiltonianum** Mart.; F.B.I. as *E. oryzetorum* l.c.; Ruhl. No 179. Perennial (*Mart.*) Leaves $1\frac{1}{2}$-$2\frac{1}{2}$ in. Sheaths shorter, scapes numerous, very slender. Heads conical, 1/6 in. Involucral bracts, blunt; floral acute, hardly acuminate. Sepals narrow, 2 only; petals 3 oblanceolate. Plate 33.

Var *a typica.*

Assam & southwards to Tavoy.

Var *b minor.* (King at Siliguri 1878 in Herb. Calc.); Leaves $\frac{1}{2}$-1 in. Scapes 1-2 in. Heads 1/8 in.

Assam; Siliguri.

Var *c minima,* (Meebold 9898!) leaves linear $\frac{1}{2}$-$1\frac{1}{2}$ in. Scapes capillary 1-4 in. Heads 1/8 in. Flowers few.

Penisular India; Western Ghats at Castles Rock.

If the sheet Wall. Cat. 6069 in Herb. Calc. given this name is correctly so numbered, the plant is quite distinct from *E. oryzetorum,* not an immature state as given in F.B.I. l. c. Varieties *a*, *b* and *c* appear to me to grade into each other, though a and *c* would certainly seem distinct.

36. **E. Edwardii** Fyson sp. nov. (Clarke No. 34327 in Herb. Calc!) Caulis perbrevis. Folia 2-5 cm. longa, 4-6 mm. basi lata, acuta, glabra, tenuia. Pedunculi 6-20 cm. tenues. Capitula 3-5 mm obconica sed demum globosa, bractae involucrantes nec reflexae, 4 mm. longa, scariosae, glabrae, ellipto-acutae, quam bractis flores superantibus paulo longiores. Haec bractae glabrae, obovato-acutae, pallido-nigrae. Receptaculum altum villosum. Flos ♀ Sepala 2, tenuia; petala 2 linearia, aut. o. Semina 3. Flos ♂ Sepala 2? in spatham connata; petala o. antherae 6, nigrae. Plate 34.

Himalayas: Sikkim; Bengal; Chota Nagpur.

Scapes 3-4 times the leaves. Heads gobose or nearly so, in bud over-topped by the acute involucral bracts.

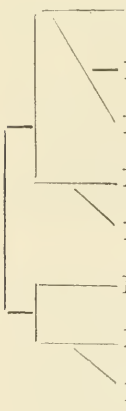
This species stands in much the same relation to the other two members of this section as *E. minutum* to the first two species of the next section. It represents a corresponding stage in the reduction of the floral parts accompanied by a lengthening of the involucral bracts. It is possible that var. *minor* and *minima* of the previous species should be included in it. The whole series forms a perfect example of gradual reduction in the floral parts.

VI. CRISTATO-SEPALAE

The sepals of the female flowers are deeply boat-shaped with the keel thickened or expanded into a wing or crest, which may be lobed or even pectinate. One sepal may be absent, otherwise the flowers are normal. The floral bracts are glabrous and except in the last two of the series hyaline. The leaves and other vegetative parts are also glabrous. All are marsh or land plants, none grow in running water.

The group appears to have progressed in two directions: perhaps it should really be divided into two sections. One with increasing floral bracts ends in *E. echinulatum* where they have long linear points and the petals are absent; the other with short bracts, developed along the line of decreasing width of the petals, till in *E. sexangulare* they are linear with long hairs. *E. Thomasi*, may be a derivative of this latter species. (See E. Thwaitesii No. 14, for similar development.)

TABLE OF PROBABLE RELATIONSHIPS.



E. Margaretae	... Western Ghats.
E. Elenorae	... Western Ghats.
E. minutum	... Western Ghats of Mysore and Mount Abu.
E. stellulatum	... Western Ghats, Bombay to Malabar.
E. echinulatum	... Burma to Malay.
E. cuspidatum	... Western Ghats.
E. sexangulare	... Western Ghats, and Burma to Malay.
E. Thomasi	... S. India.

Key to the Cristato-sepalae.

* Heads under 1/6 in. diameter. (Mt. Abu to Malabar)

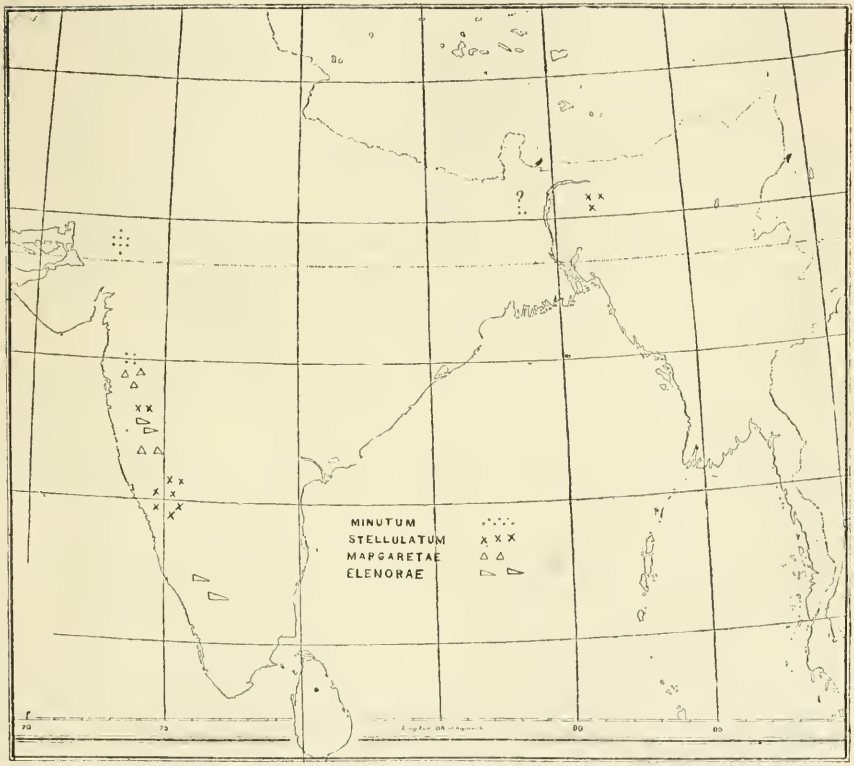
Heads 1/8 in. conical, female sepals 3, equally crested ... 37 E. Margaretae.

Heads 1/8 in. conical, female sepals unequal, 1 not crested ... 38 E. Elenorae.

Heads 1/8 in conical, obconic, the involucral bracts longer than the floral ... 39 E. minutum.

** Heads 1/6 inch, floral bracts acuminate. (Burma) ... 41 E. echinulatum.

CHRISTATO-SEPALAE.



Map 2. Showing the distribution in India of certain species of the section Cristato Sepalae.

*** Heads 1/3 inch or more.

† Floral bracts much longer than the flowers giving the head a glistening white, echinulate appearance (Western Ghats) ... 40 E. stellulatum.

‡ Floral bracts short, closely imbricate, involucre horizontal.

Leaves oblong, with cuspidate apex. (Western Ghats) ... 45 E. cuspidatum.

Leaves linear to oblong-lanceolate, not cuspidate (Western Ghats and Burma) ... 46 E. sexangulare.

Heads globose, peduncle thickened below it ... 47 E. Thomasi.

37. **E. Margaretae** Fyson, sp. nov. (Fyson 3839! Sedgwick 2979!) Caulis perbrevis. Folia angusto-linearia aut setacea, 3-5 cm., longa, glabra. Pedunculi 5-10 cm., tenuia. Capitula 1.5 mm, lata, demum conica, alba, glabra. Bractae involucrantes glabrae, straminea. Bractea flores superantes similes, glabrae aut sub-pubescentes, acutae. Flores tri-meres. Flos ♀ sepala æqualia, apice acuta, medio naviculari-carinata, carina spongiosa; petala oblanceolate, ciliate. Flos ♂ antherae nigrae; petala et sepala 3.

Bombay and Mysore on the Western Ghats, Rudrasiri, Bidi (Belgaum District).

The peduncles are very slender, and the pale glabrous conical heads are very similar to those of *E. Hamiltonianum* var. *minor* (sp. No. 35). The three female sepals are all equal, winged and acute above the wing, otherwise the plants are very like the next species.

This may be *E. heterolepis* Steud, but I have not seen any sheet so named. Ruhland lc. s. described that species as having broader leaves and with the inner involucral bracts obtuse and lacerate. See also note in Appendix I.

38. **E. Elenorae** Fyson, sp. nov. (Gudalur 15 XI 88, in Herbi Madras!) Proxime affinis species *E. Margaretae*, sed sepala feminis floris inaequalia. Plantae robustiores. Folia latiora, ad 2.5 mm. Capitula majora, ad 3-4 mm. lata. Receptaculam altius, villosum. Bractae involucrantes acutae aut cuspidatae. Sepala floris ♀ inaequalia, primum et secundum carinata; tertium paulum brevius, valde angustius, ecarinatum. Flos ♂ antherae nigrae, petala et sepala 3. Plate 35.

Peninsular India; on the Western Ghats at Mahabaleshwar, Castle Rock, etc., Gudalur.

Leaves 1-3 in. by 1/16-1/10 in. at the middle, 5 or 6-nerved Scapes numerous, variable in height 2-5 in., glabrous 4 or 5-ribbed. Involucral bracts elliptic-acute, at first horizontal later reflexed.

Floral similar, slightly acuminate, sparingly pubescent. Receptacle tall, hairy. Female sepals 3 unequal, one much the largest, the smallest not crested.

These last two species are very closely connected and might perhaps be considered one species, but *E. Elenorae* seems to be always the robuster, and in *E. Margaretae* I have never found the female sepals at all unequal.

39. **E. minutum** Hook. f.; F.B.I. vi, 579, No. 28; Ruhl. No. 190. Whole plant very small. Leaves linear 1/2-3/4 in. long, from a broad 3-5 nerved base. Scapes numerous, very slender 1½-2½ in. Head obconic, the involucral bracts 1/8 in. long-glabrous, scarious, elliptic-acute and covering the floral. Floral bracts oblong, acute. Female sepals 2 only, narrow, with a pectinate crest along the upper half of the back; petals 0. Male flowers normal, petals small. Seeds oblong elliptic, reddish brown. Plate 36.

Rajputana; Mt. Abu: Peninsular India; Mysore and Kanara on the Western Ghats.

This species might be mistaken for a small and meagre form of *E. xeranthemum*.

40. **E. stellulatum** Koern.; F.B.I. vi, 579, No. 26; Ruhl. No. 153. Leaves broad and thin 2-3 in. acute. Scapes several slender 3-6 in. Heads 1/3 in. Involucral bracts lanceolate-acute, reflexed. Floral similar, spreading, much longer than the flowers, making the head a glistening stellate globe. Female sepals 2, strongly crested on the back; petals 3, oblanceolate, very hairy. Male flower normal, 3-merous.

Bombay and Malabar; on the Western Ghats. Abundant on the lake side at Mahabaleshwar in Oct. (*Sedgwick*).

41. **E. echinulatum** Mart. (Wall Cat. 6082 in Herb. Calc!) F.B.I. vi, 579, No. 26; Ruhl. No. 177. Leaves acute or aculeate, 1/2-3 in. Scapes many, 3-6 in., slender. Heads 1/6 in. globose except for the horizontal base, very echinate by the acuminate floral bracts. Female sepals 2 only, winged down the back; petals 0. Male flowers normal, 3-merous. Plate 37.

Burma; Kelaben, Tavoy.

42. **E. cuspidatum** Dalz. (Dalziel No. 138 in Herb. Calc!) F.B.I. vi, 581, No. 31; Ruhl. No. 168. Stem discoform. Leaves 1-4 in. by 1/6-1/4 in. exactly oblong up to the round and apiculate or cuspidate apex above 7 nerved. Scapes several 8-15 in. Heads 1/4 in. diam., globose, white. Floral bracts cuneate, obovate, hairy. Sepals of both sexes 2 only (F.B.I. has "3, one flat") female sepals deeply

boatshaped and enlarged down the back. Seeds oblong, quite smooth. Petals 3, linear-lanceolate, unequal. Plate 38.

Peninsular India; N. Mysore; Kanara, at sea-level, Malabar, and Concan.

The leaves make this a very distinct species.

Var. *bracteata*, (Talbot. No. 639 in Herb. Calc!) Involucral bracts longer than the head.

43. **E. sexangulare** Linn. (Wall. Cat. 6068 in Herb. Calc!); F.B.I. vi, 580, No. 29; Ruhl. No. 186, and E. longifolium Nees., Ruhl. No. 25; Stem 0. Leaves 1/8 to 3/4 in. wide by 4-12 in., many ribbed, flat. Scapes many up to 18 in., stiff. Heads 1/3 in. or less, hemispherical or conical with eventually a truncate base. Involucral bracts pale, shining. Floral bracts broadly obovate, cuspidate. Flowers 3-merous or 2-merous. Female sepals two very boat-shaped, one flat or absent. Petal linear, with long hairs springing from its base, the whole forming a brush of slender filaments. Seeds flat ovate or subglobose with parallel darker lines, and covered with peltate hairs. Plates 39 and 40.

On the western side of South India down to Ceylon, and throughout Burma and the Malay Peninsula.

The plants of the Western peninsula are larger on the whole than those of the Eastern, which are frequently 2-merous. In the F.B.I. the latter is given as a variety and perhaps it should be so considered, but in every other respect the two forms are identical and it would always be necessary to dissect the heads to determine the point. The Mysore plants connect them. For this reason the separation of these forms as two distinct species, *E. sexangulare L.* & *E. longifolium* Nees, widely apart in different sections of the genus as is done by Ruhland seems particularly unhappy. Koerniche though he separated the American 2-merous species, placed these two together observing that the 2-merous flowers and acute not shortly acuminate floral bracts distinguish them.

44. **E. Thomasi.** Fyson sp. nov. (Meebold 9104 et 9899 in Herb. Calc!) Habitu specii *E. Thwaitesii* Hook. f. similis, sed capitulum globosum, involucrum reflexum, sepala duo. Caulis per-brevis. Folia caespitosa, lanceolata acuta, mucronata, glabra, 5-10 cm. longa, 0.4 to 1.0 cm. lata. Pedunculi paulo ad duplice longiores, glabri; sub-capitulo paulo crassi. Capitula globosa. Bractae involucrantes brevae, reflexae. Bractae flores superantes rhomboidocuncata summodorse puberulae. Flos. ♀ sepala 2, naviculari-concava; petala 3, angustissima linearia, longis pilosis barbata magnis glandulis instructa. Semina, oblonga, fusca. Flos ♂ sepala 2, angusta; petala 3; antherae nigrae. Plate 41.



ERIOCAULON STELLULATUM *Koern.*

Peninsular India; on the Western Ghats, Salsette, Khandala, Castle Rock, Tirthahalli!

Stems tufted. Leaves glabrous, lanceolate or oblanceolate acute or mucronate. 2-5 in. by 1/3 in. at widest. Scapes twice as high or less, thickened below the very globose or truncate heads, which are white by the thickly puberous exposed back of the floral bracts. Receptacle tall hairy. Sepals in both sexes 2 only; deeply boat-shaped and thickened along the keel. Female petals linear with long basal hairs. Anthers black.

A very distinct species, allied probably to *E. sexangulare* L. but with the keel of the female sepals less developed. The slight but distinct thickening of the peduncle just below the head is very striking. (See notes on *E. bombayanum* Ruhl. and *E. neesianum* Koern. in Appendix I.)

Other species belonging to this section are :—

E. australe R. Br. (in Herb. Calc. "China"!) closely allied to *E. sexangulare* L., being similar in the head and the female sepals.

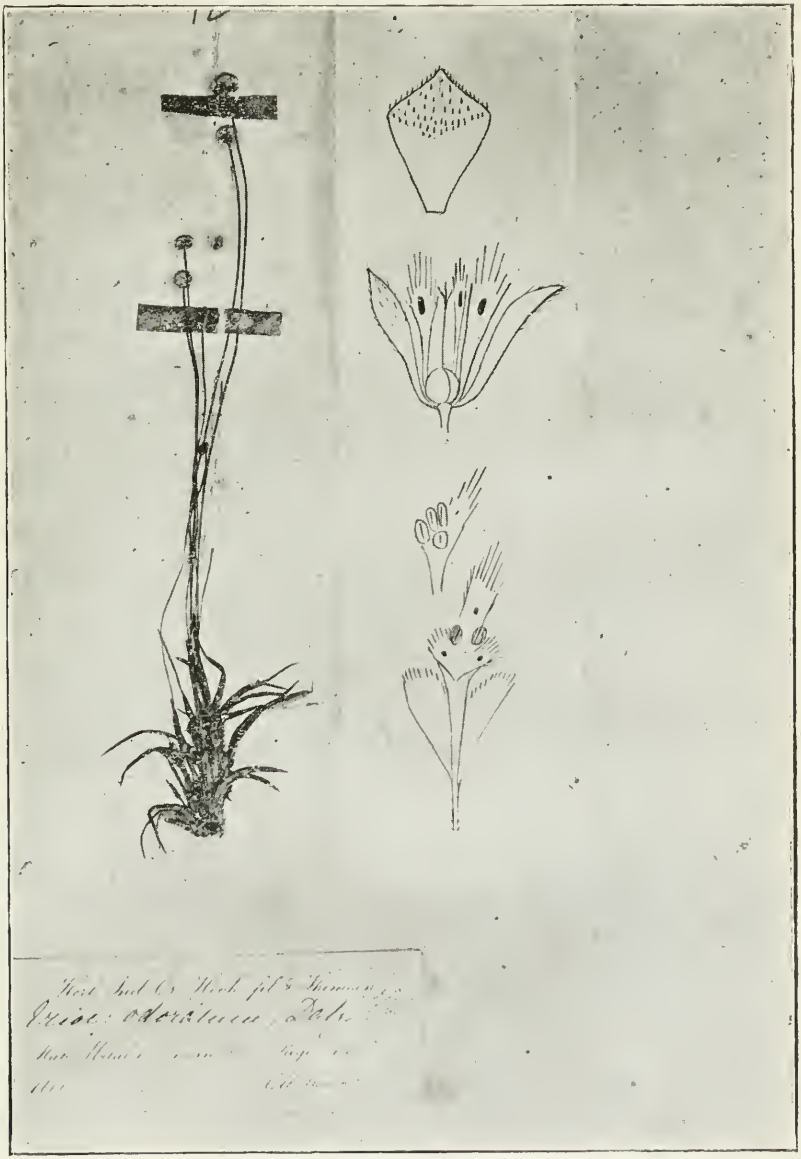
E. alatum (in Herb. Calc. Coll. Col. Pirie. Cochin China;) with glistening ovoid heads and female sepals as in *E. cuspidatum* Dalz.

There are also in Herb, Calc. two other sheets one Coll, Loher. No. 1602 in Phillipines is very similar to the *E. alatum* (above) but the wings of the female sepals are coarsely toothed. The other has a label "ex herb hort, Kew" and a number 1168, but no other identification mark. Two of the female sepals are crested, one not deeply boat-shaped and not crested.

Ruhland in his clavis VI has a small group of three Indian, five African and one Australian species with the female sepals "dorsocristatæ-alatæ." The Indian consist of (1) *E. heterolepis*, Steud referred to above, (2) *E. pseudequinquangulare* Ruhl. which also I cannot find but which he says is very closely allied to *E. heterolepis*, and (3) *E. trilobum*, but the Calcutta sheets of this last species have certainly no crests to the sepals. In his clavis V. (flowers reduced) *E. bombayanum* Ruhl. apparently belongs to this series, but I have not seen it. In his Clavis I, (dimerous flowers) he has in addition to *E. longifolium* Nees, several American species with winged female sepals, one *E. guianense* Koern, being figured (p. 37).

(To be Continued.)

I am indebted to Messrs Blatter and Hallberg for the photograph reproduced in plates 12, 17 and 39.



ERIOCAULON ODORATUM *Dalz.*
(2 sepals only shown of female flower).



ERIOCAULON LONGICUSPIS *Hook. f.*



ERIOCAULON ATRATUM *Koern.*



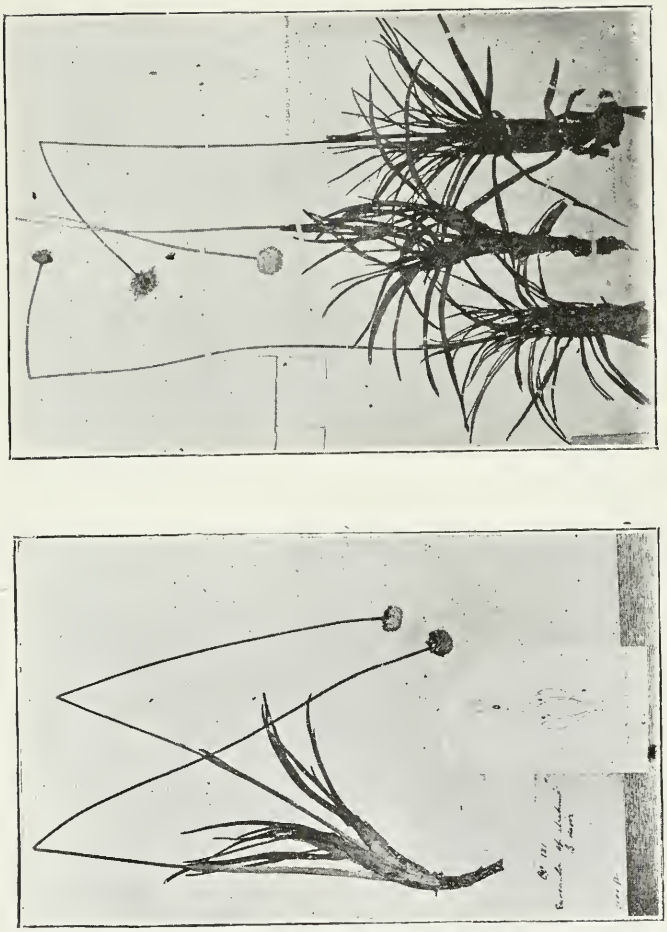
ERIOCAULON CEYLANICUM *Koern.*



ERIOCAULON CEYLANICUM *Koern.*
Var. *subcaulescens.*



ERIOCAULON ROBUSTUM *Steudel.*
(The right hand plant was 30 inches high).

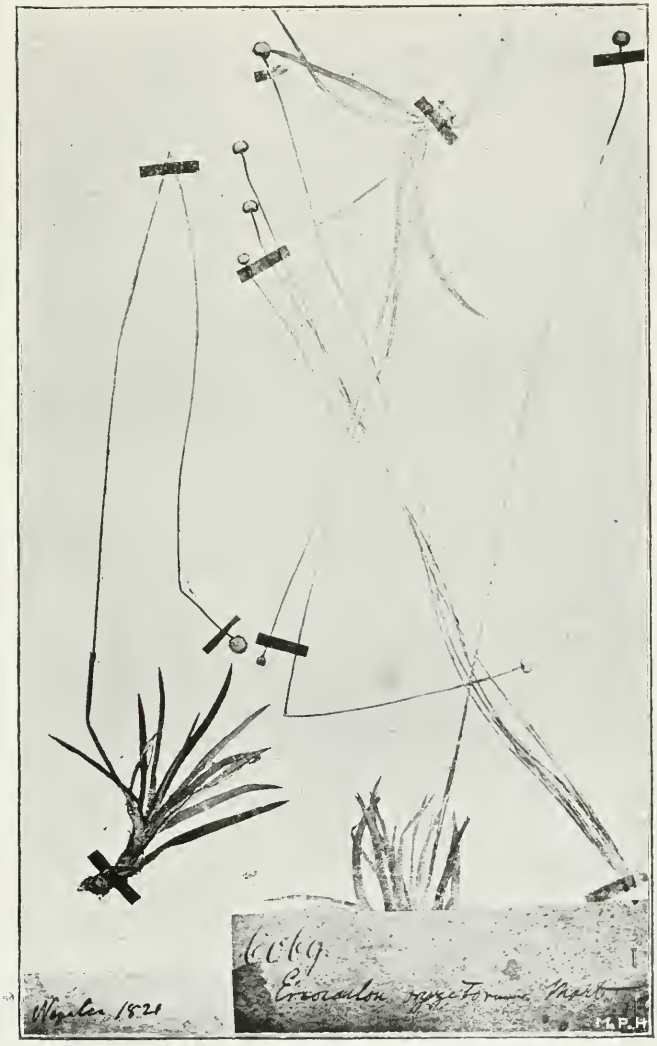


ERIOCAULON ROBUSTUM *Steud.* Var. *caulescens.*



ERIOCAULON CRISTATUM *Mart.*

INDIAN SPECIES OF ERIOCAULON, Pl. 32.



ERIOCAULON ORYZETORUM *Mart.*



ERIOCAULON HAMILTONIANUM *Mart.*



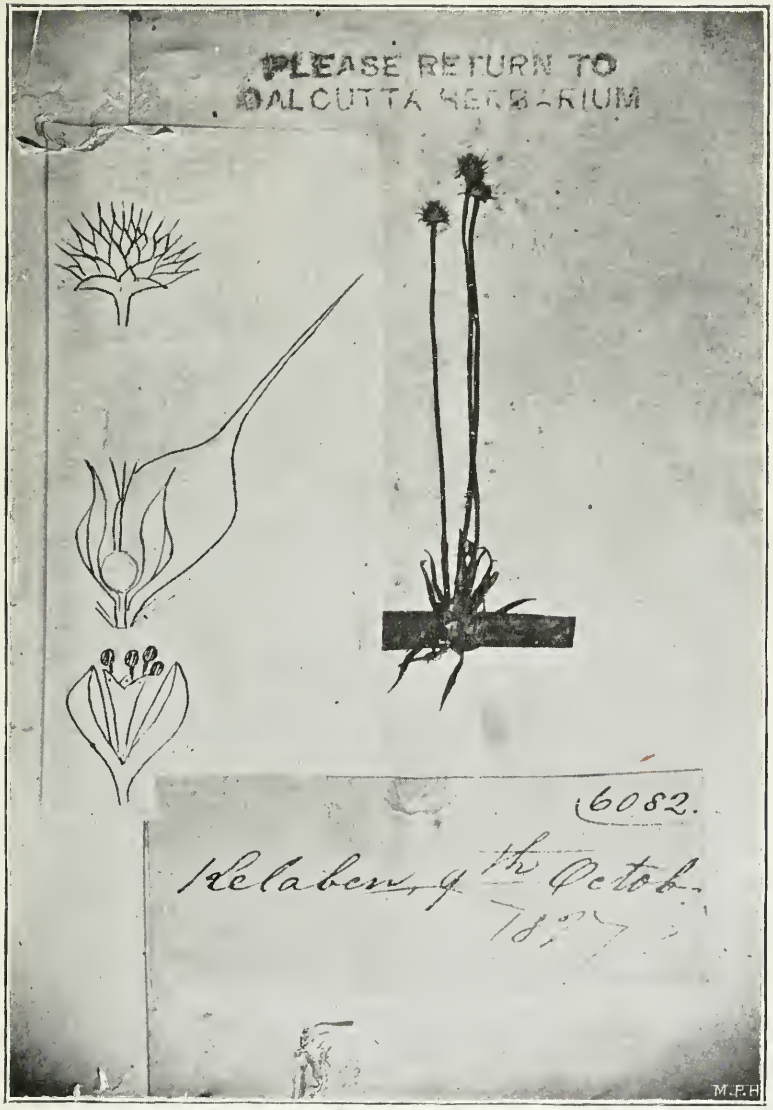
ERIOCAULON EDWARDII *Fyson.*



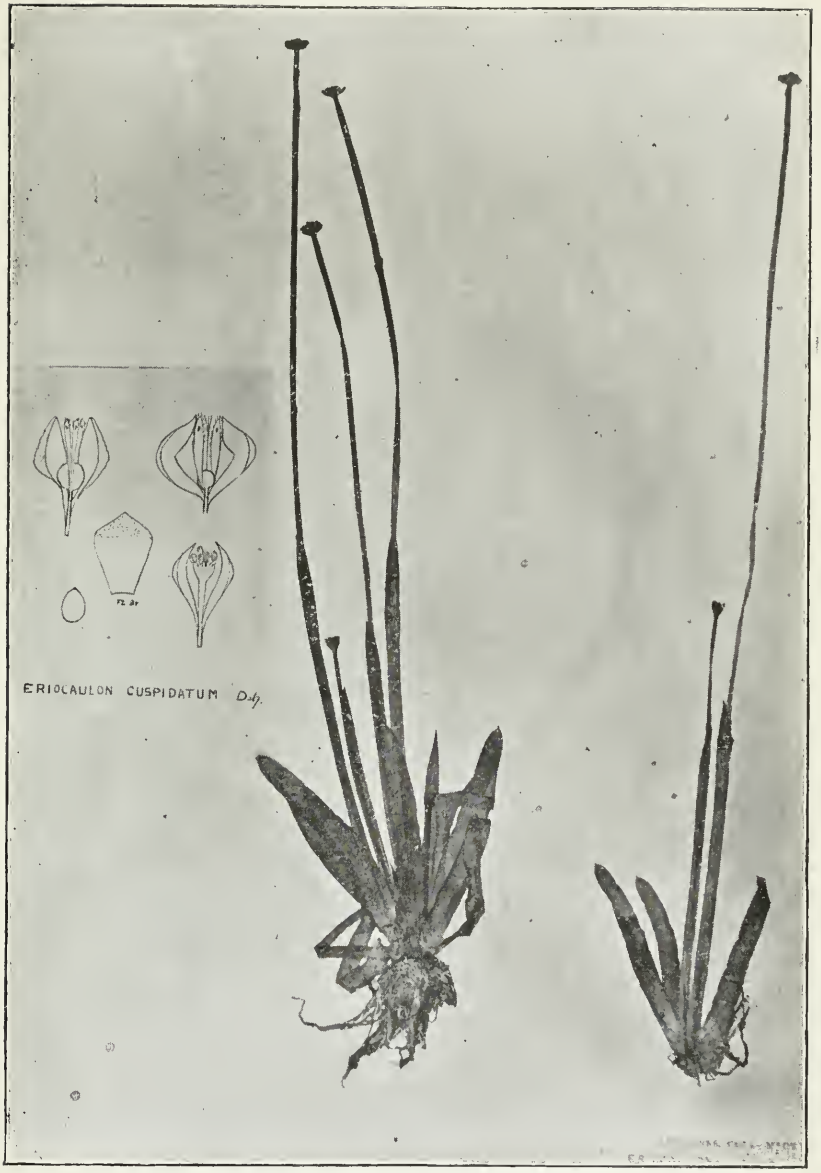
ERIOCAULON ELENORAE *Fyson.*



ERIOCAULON MINUTUM *Hook.*



ERIOCAULON ECHINULATUM *Mart.*



ERIOCAULON CUSPIDATUM *Dalz.*



ERICCAULON SEXANGULARE *Linn.*
(From photo of figure in Wall. Pl. As. Rar. iii. t. 240.)



ERIOCAULON SEXANGULARE *Linn*



ERIOCAULON THOMASI *Fyson.*

NOTE

Proliferation in Opuntia dillenii.

While making some observations on the prickly pear of this place (Opuntia dillenii) I came across an abnormality in the flower-bearing joint of the plant which consists of a young fruit bearing two smaller fruits one on either side developing from the areolae near the scar of the perianth leaves.

This abnormality which is a case of proliferation has been recorded by Britton and Rose* for some other species of Opuntia *e.g.*, O. arbuscula, O. fulgida, O. decumbens, O. vulgaris, etc. and in Pereskia sacharosa. Several bushes of O. dillenii were examined by me for more instances of this malformation and as none were found it appears to be a rare phenomenon in this species.

I kept the specimen under observation in expectation of its becoming more prolific but unfortunately after one month the bush was cut by some one as it was on the road side and in a state of overgrowth and I could content myself only with the broken joints.

The abnormality is here recorded as being part of a wide phenomenon characteristic of the Cactaceae and the frequency with which it occurs in certain species more than in others will probably be of interest when the physiological causes underlying proliferation are considered.

Agricultural Research Institute, Coimbatore, *17th October, 1921.*

P. S. Jivanna Rao.

* The Cactaceae by N. L. Britton and J. N. Rose; Carn. Inst. Washington. Pub. No. 248, Vol. I, 1919. Also see Year Books of the same Institution 1912 to 1915, Fruit development in the Cactaceae by D. S. Johnson.

CURRENT LITERATURE.

Algae

Hodgetts, William, J. A New Species of Spirogyra. *Ann. Bot. Vol. XXXIV, 1920, 519—524.*

The author gives a description of *Spirogyra colligata*, a new species from Worcestershire. The Alga presents many interesting features the most remarkable of which is the curious H shaped clamp connections between every pair of contiguous cells of the filament. A detailed description of these clamp connections is given. The author thinks that these clamp connections are probably helpful in keeping the cells of the filament from breaking up into individual cells through excessive turgor pressure.

Certain individual cells of the filament show curious coiling which the author thinks may be useful in grappling the filaments together and thus aiding scalariform conjugation.

Three methods of conjugation were observed, (1) scalariform, (2) lateral and (3) terminal. Terminal conjugation, like lateral conjugation, takes place between two adjacent cells of a filament, but is brought about by the growing out of one extremity of the cell through the cross wall.

This terminal conjugation and the H shaped clamp connections are unique features and, according to the author, have not been observed in any other recorded species of *Spirogyra*. On account of the presence of these curious clamp connections and the variety of the modes of conjugation, the author considers the species to be the most highly evolved, if not the highest, of all the known species of *Spirogyra*.

M.O.P.

Physiology

Hill Leonard, M.B.,F.R.S. The Growth of Seedlings in Wind. *Roy. Soc. Proc. B. Vol. 92, p. 28.*

The author conducted some experiments to study the effect of wind on the germination and growth of seedlings. Mustard and cress seeds were grown on lamp wicks which were kept moist by their ends dipping in a basin of water. The seedlings were subjected to continuous wind from a blower fan which was running day and night with smoothness without stoppage during the whole course of the experiment which lasted many weeks. Seeds were also grown in still air as controls. The following results were recorded by the author. The drying of the upper surface of the seeds, even though the lower surface may be wet, was sufficient to stop the growth. Seeds which were grown in the wind were soon bent and twisted close to the wick very nearly horizontally. The wind exposed seedlings showed less growth in length, had more solids, less water, more ash, less protein and presumably

more cellulose. No root-hairs were developed on the wind exposed seedlings while plenty of root-hairs were formed on the control seedlings kept in still atmosphere.

The author thinks that the retardation of growth in the seedlings is not due to the shaking produced by the motor, because seeds sheltered from wind but submitted to the shaking grew quite as well as the control seeds. He thinks "that the stunting effect produced by the wind is not only due to a less favorable wetting, but to greater cooling. The growing point may be robbed by wind of heat which is produced in the cellular growth processes—heat which facilitates growth."

M.O.P.

Printed and Published for the Proprietor by W. L. KING. at the Methodist Publishing House, Mount Road, Madras.

Note to Contributors

It would greatly assist the Honorary Editor if the following rules are kept in mind by Contributors :—

All matter for the printer should be typed and on one side of the paper only. The name of a genus should begin with a capital letter, but that of the species only when it is adapted from a proper name. No comma should be put in after the specific name and before that of the founder of the species. The Editor will see to the type.

Illustrations in line should be drawn in India ink on smooth paper or card, and will reproduce best if at least twice as large as they will appear in the Journal. Photographs for reproduction by half-tone process must be on glossy paper and should be strong bright prints. Good results cannot be obtained from over-exposed negatives or weak prints.

Abstracts of papers in other Journals should begin with the author's name and initial, followed by the title of his paper and where it is published: the abstract itself beginning a new line.

Twenty-five reprints of original papers will be supplied free and more may be had on payment if asked for at the time the contribution is sent in.

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